RECRUITING AND TRAINING FUTURE SCIENTISTS:

HOW POLICY SHAPES THE MISSION OF GRADUATE EDUCATION

Merrill Series on
The Research Mission of Public Universities

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INTRODUCTION

Mabel L. Rice
The Fred and Virginia Merrill Distinguished Professor
of Advanced Studies and
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University of Kansas

This year marked the seventh annual research policy retreat hosted by the Merrill Center in Valley Falls, Kansas. Our topic in 2003 was: *Recruiting and Training Future Scientists: How Policy Shapes the Mission of Graduate Education*. The future of scientific inquiry depends on the recruitment of high achieving young people and robust graduate-level research training experiences. This requires financial resources for student support, focused attention on graduate level curricula at the university level, and a cadre of productive faculty researchers to serve as mentors. In the pressure of recent funding declines, it can be a challenge for public universities to marshal these resources and prioritize the training of future researchers. During this retreat we focused on the challenges of graduate education from the perspective of recruiting and training future scientists.

Two keynote speakers provided views from the top leadership levels in the U.S. and Canada. Debra Stewart, President of the Council of Graduate Schools, spoke about challenges to graduate education in light of the push for curriculum reform, budget cuts, and new rules on immigration. She urged universities to continue broadening the talent pool as affirmed recently by the Supreme Court in the Michigan decision. Martha Crago, President of the Canadian Association of Graduate Studies, gave an update on initiatives in Canada, and offered her insights on how to build programs for the future during hard times, based on her experience as an administrator at McGill University. Both speakers addressed key issues about retention of students in the doctoral track, efficiency in time to degree, and making the rules of the game transparent.

Twenty-three administrators and senior faculty came as teams from public universities in the Midwest: Iowa State University, the University of Nebraska-Lincoln, the Nebraska Medical Center in Omaha, the University of Missouri-Columbia, Kansas State University, the University of Kansas and the KU Medical Center in Kansas City, Kansas. Also joining us were Keith Yehle from the office of Senator Pat Roberts and David Kensinger from the office of Senator Sam Brownback.

The 2003 topic built on discussions at the six previous retreats in the Merrill series *The Research Mission of Public Universities*. Our benefactors, Virginia and Fred Merrill, to whom we are deeply appreciative, support these conferences. The inaugural event in 1997 focused on pressures that hinder the research mission of higher education. In 1998, we turned our attention to competing for new resources, and ways to enhance individual and collective productivity. Michael Crow, our keynote speaker that year, encouraged us to identify niche areas for research focus, under the premise that it was most promising to do selective areas of investigation at the highest levels of excellence. In 1999, we examined in more depth cross-university alliances. Keynote speaker Luis Proenza encouraged participants to think in terms of “strategic intent” and he highlighted important precedents in university-industry cooperation as well as links between institutions. In 2000, we focused on making research a part of the public agenda. We heard from George Walker who encouraged us to meet the needs of our state citizens, business leaders and students who are quite able to "carry our water" and champion the cause of research as a valuable state resource. In 2001, Joan Lorden brought to the table her experience with the topic of evaluating research productivity. She provided a valuable overview of key elements to consider when selecting measures for evaluating performance, with a focus on the very important National Research Council (NRC) study from 1995. Our keynote speaker in 2002 was Martin Apple, President of the Council of Scientific Society Presidents. In light of 9/11, he proposed unique ways that universities can lend expertise on bioterrorism, while at the same time remaining faithful to the task of generating new knowledge that can lead to societal benefits such as better health and sustainable energy sources.

As always, the pages of the Merrill white paper reveal many fascinating perspectives, and a frank examination of the complex issues faced by research administrators and scientists every day. It is with pleasure that I encourage you to read the papers from the 2003 Merrill policy retreat on *Recruiting and Training Future Scientists: How Policy Shapes the Mission of Graduate Education.*

EXECUTIVE SUMMARY

KEYNOTE ADDRESS – Day 1

Debra Stewart
President, Council of Graduate Schools

- Graduate education is one of the United States' most successful enterprises, and it is growing. More than 220,000 international graduate students enrolled in U.S. programs. Graduate education enjoys strong support because the research enterprise contributes to the economy.
- The Council of Graduate Schools directed the "Preparing Future Faculty" initiative as early as 1993, and other national reform studies have followed. These include: the Carnegie Initiative on the Doctorate, the Re-envisioning the Ph.D. program, the Responsive Ph.D. Project and the Sloan Professional Science Master's program.
- Studies of doctoral education show a dissatisfaction by students with 4 areas: breadth of the curriculum and opportunities for interdisciplinary study; information about the process and outcomes of study before they begin their educational programs; attention to job skills that will be required; career guidance and job placement (including non-academic jobs).
- Assessment has always been critical to the success of graduate education. Interdisciplinary programs are important for the student's learning experience and for research, but we have not yet devised effective ways to describe and compare these programs when making awards in an assessment-based competition.
- State universities are experiencing some of the most dramatic budget cuts in decades and this inevitably has an impact on state-supported teaching and research assistantships for graduate students.
- To increase the likelihood that our graduate students will complete their degrees, reform-based research tells us: certain combinations of funding are better than others; placing time limits on support encourages graduation; women benefit from being research assistants; participation in the academic life of a department is important and funding mechanisms can encourage this. What we know can be built into the federal support programs for graduate students—but will this bind the faculty PI's in a way that damages the effectiveness of the targeted research project?
- Graduate education in the U.S. is dependent on international students—particularly in the fields of engineering, computer science, math and economics. The policies enacted in the wake of 9/11 will inevitably slow the flow of foreign talent to the U.S. The United States must develop a robust domestic talent pool for doctoral study in science and engineering, or it will approach a national crisis in education.
- The recent U.S. Supreme Court decision on Michigan has engendered a good discussion about how America can prepare effective pathways to

graduate school for historically disadvantaged groups in order to meet its future workforce needs. We must redouble our efforts to expand graduate preparation in the U.S.—and we must graduate those whom we admit to our programs.

KEYNOTE ADDRESS – Day 2

Martha Crago

President, Canadian Association of Graduate Studies and Dean of Graduate and Postdoctoral Studies, McGill University

- The Canada Graduate Scholarships were created in 2003 to meet the federal government's goal of moving Canada from 15th to 5th in the world in research and development. These scholarships provide $35,000/year to doctoral students for 3 years and $17,500 to master's research students for one year. In Quebec, the government grants full tax exemption on all merit-based graduate scholarships. This situation is putting pressure on faculty to increase the amount of postdoctoral fellowships (from their own grants) because graduate students are now funded at a comparable level.
- The top research intensive universities in Canada investigated the actual times to degree and graduation rates of their students in graduate school and found that the minimum rates in the humanities and social sciences were alarmingly low. Median times to completion were also higher in the humanities and social sciences than in physical and life sciences. We also investigated the patterns of withdrawal from graduate study. Some students appeared to run out of steam or money after as many as 8 or more years of studying—this is an educational tragedy.
- Studies about how to retain graduate students leave us with opportunities for reform: if we know that participation in a group is important, then funding agencies should investigate the impact of graduate student funding mechanisms such as training grants, that support involvement of students with others. Mechanisms for setting objectives and tracking progress to degree should be transparent and widely used. Students should be counseled by advisors and administrators to withdraw earlier rather than later if they are ill suited to research and scholarship. Universities should consider failing students for documented lack of research progress.
- Students want more in the way of professional skill training. This could include: learning to present their research to various audiences; learning to write grants; learning about the full-range of employment possibilities; preparing a curriculum vita; and practice interviewing for a job.
- Students want to know more about their intellectual property rights. This includes: the meaning of the copyright on their thesis, marketing and proprietorship of a patent, and authorship of a journal article. Because universities increasingly have non-university partners in research, students need guidebooks to explain their universities' intellectual property policy as it relates to graduate students. They need to know whether they

can share their findings with others in publications and seminars. Should they be paid by their supervisors' spin-off companies? Can students use equipment in their supervisors' spin off company? And universities should offer courses to graduate students in the responsible conduct of research and professional ethics.

- There are many unresolved issues in the postdoctoral experience: Do we need postdoctoral administrative offices? Should postdocs be paid a salary or a fellowship? Should they receive benefits? Should they have to obtain a certain score on a TOEFL test of language skills? Quebec has set a legal precedent defining the postdoctoral experience as a research internship, not an employment category.

IS ACADEMIC RESEARCH SUSTAINABLE?

Robert E. Barnhill
President, Center for Research, University of Kansas

- Federal support of research is under pressure because of tax cuts, the poor economy and more focus on post-9/11 issues. Because the federal government tends to under-fund its mandates, no university recovers the actual cost of federally funded research.
- African Americans, American Indians and Hispanics are under-represented in our science and engineering programs. We need leadership to develop this talent pool.
- State support of public universities is declining and will not proportionally increase after and if the economy improves.
- We must make the case for the economic benefits of university research. In Kansas, we generate 42 jobs per $1 million of investment in university research and development. KU's research produced over 10,000 jobs in fiscal year 2002 according to AAU estimates.
- If the promotion and tenure committees do not reward interdisciplinary research, then a university will not do as well nationally as it could. Big-time research occurs in interdisciplinary teams. Research centers have been important in KU's institutional success.
- KU achieved a 28% increase in federal funds between 1996 and 2001, with the Lawrence campus seeing a 44% increase in this market share.
- A nationally agreed-upon benchmark for return on investment in academic research is 4:1 – one internal dollar should produce four external dollars. At the KU Center for Research, we calculate return on investment at our research centers by dividing research expenditures or indirect cost return by the total center investment (budget allocation plus returned overhead). For the humanities, we developed qualitative performance measures that involve the number of prestigious awards.

FIRST PANEL OF RESEARCHERS

Dan Monaghan, Professor of Pharmacology, University of Nebraska Medical Center

Janice Buss, Professor and Director of the Molecular, Cellular and Developmental Biology Graduate Program at Iowa State University

John Colombo, Professor of Psychology and Associate Dean of the Graduate School, University of Kansas

- Many students do not understand the demands of graduate school or postdoctoral training. It is important to help prospective students know what will be expected in terms of workload, time to degree, and the job market for Ph.D.'s. If the selection process were more careful, there might be less attrition in graduate school.
- Interdisciplinary programs are attractive to high caliber students. Faculty join interdisciplinary programs often because this gives them access to excellent students. Students like to be on the leading edge of research discoveries.
- To have strong interdisciplinary programs and recruit good students, we must invest. These programs are not typically part of the regular budgeting process that focuses on undergraduate education and is administered through departmental and college channels. Interdisiplinary students should not always be last on the list when allocating teaching assistantships or emergency funding. Tuition waivers, as well as stipends, are attractive.
- Most faculty believe that graduate education—especially doctoral education—is central to the mission of the research university. The interplay of research and graduate education is a reciprocal and transactional process: when an institution brings in visible and well-funded researchers, this attracts good graduate students which in turn makes the institution more desirable to faculty candidates, which will enhance the reputation of the graduate program.
- Traditional doctoral education is at risk today because it is considered inefficient and costly in terms of resources. We must address two problems: attrition and time to degree in order to improve efficiency and increase the research productivity of students and faculty.
- Rather than be more selective in admissions as a way to decrease attrition, we should improve our administration and advising. For example, we should set reasonable time limits for completion of the degree and establish a probationary period once a student is admitted. Faculty advisors should make expectations explicit. Mentors should integrate new students into existing lines of research by, for example, suggesting that the student take on a programmatic extension of the faculty member's own work—this has a high probability of providing real research credential and the student can seek more independent contributions later in the graduate career. The faculty can also foster a culture where research products are generated in a timely manner.

PANEL OF RESEARCH/GRADUATE ADMINISTRATORS

R.W. Trewyn, Vice Provost for Research and Dean of the Graduate School, Kansas State University
Jim Coleman, Vice Provost for Research, University of Missouri – Columbia
Ellen Weissinger, Executive Associate Dean of Graduate Studies, University of Nebraska – Lincoln

- Recruiting science students with an interest in entrepreneurship is made possible by the programs for commercialization of intellectual property at Kansas State University. Students can experience the full range of intellectual property services and commercialization practices from academic theory to real world applications. As part of the MBA Technology Entrepreneurship track, graduate interns get practical experience in technology transfer. The intern program is being expanded to include students from various science and engineering disciplines.
- The KSU Research Foundation facilitates technology transfer by licensing intellectual property to major corporations and to local start-up companies. The Mid-America Commercialization Corporation (MACC) promotes technology-based economic development in the region and works with the KSU Research Foundation on commercialization activities. MACC manages a seed capital investment fund, which can infuse early stage funding into new start-up ventures; KTEC, the City of Manhattan and the KSU Foundation are investors in this fund, and share in returns on the investments.
- The new focus on the economic benefit of research has permeated almost every aspect of research on campus. Has the focus placed on research growth overshadowed the central role of discovery, creation, innovation and scholarship in the academy? If state legislators tie support for state universities to "economic outcomes," what happens to the sustainability of graduate education if we don't deliver in clearly measurable ways?
- Identifying key areas of research investment is part of the strategic planning process for each university. If our plans focus on economic development, will we diminish the full range of graduate programs and alienate some of our key areas of academic excellence, such as the humanities?
- When we partner with the private sector in our research, we must deliver on time and within budget. This makes hiring research faculty, technical staff and postdocs more attractive than training graduate students. What effect will this have on graduate education?
- The Carnegie Initiative on the Doctorate (CID) is a multi-year research and action project to support efforts to more purposefully structure doctoral education in six core disciplines. The Department of Mathematics at the University of Nebraska – Lincoln was selected to participate in the CID. These are some of the questions the math department will answer: Is a curriculum emphasizing broad knowledge of mainstream math still

appropriate? What revisions of our curriculum and degree requirements are necessary to accommodate interdisciplinary research? How do we best prepare Ph.D. students for jobs? How can we increase recruitment and retention of underrepresented minorities? The University of Nebraska – Lincoln is attempting to institutionalize this reform project by extending the practices to other departments.

PANEL OF GRADUATE SCHOOL ADMINISTRATORS

Suzanne Ortega, Vice Provost for Advanced Studies and Dean of the Graduate School, University of Missouri – Columbia

John E. Mayfield, Associate Dean of the Graduate College, Iowa State University

- The National Science Foundation now has a "broader impact" criterion within the graduate predoctoral fellowship awards process, which includes contributions to diversity and social benefit. Because fellowship panels are given little clear-cut advice on how to evaluate and give weight to the "broader impacts" criterion, however, the process breaks down. The criterion for advancing diversity becomes in effect a secondary selection factor, used only after the traditional intellectual merit criteria are fully and equally satisfied.
- At the University of Missouri – Columbia the directors of our graduate programs have agreed that diversity should be included as one of the 3-5 core indicators we use institution-wide to evaluate program quality and make related resource decisions. This will effectively close the gap between policies and programs by making diversity a key part of the admissions process and institutionalizing access and diversity as core principles.
- In the next 10 years, if trends continue, Iowa State University may enroll more than 1/3 of all its graduate students in interdepartmental programs.
- To justify new faculty positions, the Provost of Iowa State in 2003 included interdepartmental program need as one of the three grounds that could be used. This was unprecedented. Three of the eight positions approved were interdisciplinary. If this were to become a standard operating procedure for new hires, this one policy change could have a major impact on the quality of education delivered by interdepartmental graduate programs.

SECOND PANEL OF RESEARCHERS / MENTORS

Jeffrey P. Katz, The Payless ShoeSource Professor of Business and Director, Center for Leadership, Kansas State University

Diandra Leslie-Pelecky, Associate Professor of Physics, University of Nebraska – Lincoln

Kim A. Wilcox, Professor, Department of Speech-Language-Hearing and Dean of the College of Liberal Arts and Sciences, University of Kansas

- Science and business are enjoying a renewed period of integration unmatched since the GI Bill redefined post-secondary education. The human genome project is an example of the way business can accelerate achievement in the public sector. Because the publicly funded International Human Genome Project competed with the commercial enterprise Celera Genomics in a race to map the genome, the basic research model changed to a time-dependent and outcome-focused activity with specific strategic goals. Scientists in the public sector realized that the achievement of their mission—public access to the research results—would occur only if they became business-savvy.
- As the number of commercial enterprises with academic links continue to grow, we must resolve these policy issues: developing appropriate university support services to assist in innovation value creation; training scientists, engineers and business students for commercial success in the world of innovation advancement; changing the risk/reward philosophy and alignment mechanisms in the university-industry environment; and seeking to balance the capitalization of the research enterprise.
- NSF now requires education and outreach in successful grant proposals—part of the "broader impact" requirement. Most faculty members have no training to implement effective education/outreach programs. Graduate students will eventually have to fulfill these NSF objectives when they take jobs in academia, so they should be prepared.
- The University of Nebraska was awarded an NSF GK-12 grant for training graduate students from the fields of science, math and engineering to be resources in the K-12 schools. The Graduate Fellows spend 8 hours/week in the schools and 2 hours/week planning with teachers in return for a stipend of $27,500/year plus a $10,500 cost of education allowance. The institutional effects UNL has experienced include: improving cooperation between the College of Arts and Sciences and the College of Education and Human Sciences; and increased faculty interest in teacher education. The graduate students believe it has improved their ability to work and communicate with people from diverse backgrounds.
- The American Speech-Language-Hearing Association (ASHA) was one of the first fields to require advanced training as a prerequisite to clinical certification. At the time, this was a high standard and has been successful in assuring the best possible clinical services for the public; however, this decision set in motion a trajectory that put the entire

discipline at risk. In 1951, the majority of ASHA's members were academicians interested in the study of communication processes and disorders, but by 2003, the vast majority of ASHA's members are clinical professionals who hold a terminal master's degree. At the undergraduate and master's degree level, the curriculum is now geared toward preparing individuals to be service providers. The effect is that students pursing a research career must essentially start over after the initial 6 years because they have not yet acquired the specific knowledge and scientific skills necessary for a doctoral education. Also, by formulating the curriculum around the master's degree, the field is attracting students who have little or no interest in science; they are drawn instead to a respected professional field with guaranteed employment and a good salary, which can be achieved with a master's degree.

- It is important to maintain a balance between the discipline and the profession of a field. With Communication Sciences and Disorders, the demand for trained professionals grew so rapidly that societal pressures overwhelmed longer-term scientific needs. Today, the leadership in the field is increasingly influenced by and drawn from the professions and so, at the highest levels, it is difficult to exert the influence necessary to maintain balance and to retain an academic focus.

REACTION AND CONFERENCE SUMMARY

Martha Crago, President, Canadian Association of Graduate Studies

- As universities, we need to understand ourselves better. We need to collect the same high quality data about our institutions, and analyze it, as we would do in our own disciplinary research endeavors. We can capture our transformations in facts. This can awaken us to our own local realities because it is not always easy to get the facts straight.
- Universities need to be strategic in difficult economic times—leverage funds and become enterprising. At this conference, we heard about several examples: partnering with the private sector; marketing goods produced on campus; encouraging granting agencies to increase funding to graduate students; and using lab space in the private sector for graduate students. Another technique we've used at McGill is to allocate operating funds to programs that are already successful in attracting external fellowship money for students; this reminds the community that the university must leverage external money.
- I've been told that some of the most important discoveries in science have happened by accident. It is important to preserve the university as a place where playful experimentation and free thought continue to exist. We are likely to lose something if goal-oriented research is the only research we do. It's a question of balance.
- Our students, researchers and university administrators need to develop the kind of skills that will allow them to communicate about their work to a

wider range of people. In this way more people can appreciate the work of scientists and scholars, and more children will want to become them.

- When we ask ourselves why it has been a goal to attract international graduate students, we must realize that it began as a sort of colonialism. If our aim was to educate students so they might return to their home countries and build their own higher education networks, it should be a cause of joy that graduate education in other countries is now a success —not a cause of jealousy. Education is a kind of spark that we pass on to others. Today, we should go on educating international students because for one thing they provide us with diversity at a time when we need it most. We should take the opportunity to learn from them—to educate our North American students about the world.
- In the wake of 9/11, we must think seriously about the role our universities can play in the interest of global well-being. McGill has a Middle East Peace Building Programs that brings students from Palestine, Jordan and Israel together to obtain a Master's of Social Work. Their time at McGill provides them with a safe haven to explore their commonalities and differences and to get to know each other as human beings, not just political foes. Higher education is an agent of change that develops human capacity, knowledge, and understanding.

KEYNOTE ADDRESS – Day 1

POLICY ISSUES AND INSTITUTIONAL RESPONSES:
THE GRADUATE DEAN AS THE 21ST-CENTURY JANUS

Debra Stewart
President
Council of Graduate Schools – USA

Roman mythology tells us that the god Janus hovered over the threshold of the Roman home, facing in two directions at once as he offered both protection and profit to the household. Today our graduate deans are the Janus-faced figures of the modern era, gazing in both directions to protect against threats and capture opportunities to enrich the graduate education offered to our students. As the president of the Council of Graduate Schools, the organization that provides a national voice for these deans, I spend much time reflecting on the threats and opportunities our members face.

Graduate education is by all reasonable accounts one of our country's most successful enterprises. It is large and growing larger:

Size of the Graduate Education Enterprise

- 1700 institutions
- 1.8 million students
- ½ million degrees earned annually
    - 460,000 master's degrees
    - 41,000 doctoral degrees

And all indicators are that it will continue to grow:

Trends: Undergraduate Expectations and Reality

- 75% of college freshmen expect to earn a graduate or first professional degree.
- In the first five years after earning the baccalaureate:
    - 39% have taken the GRE
    - 41% have applied for admission
    - 35% have been accepted into at least one program
    - 30% have enrolled in a graduate or first professional degree program

So, with this seemingly bright picture, what possible threats could graduate schools and graduate faculty be facing? Today I will outline four policy issues that pose the greatest challenges—and, in many cases, the greatest opportunities—for our institutions.

Each policy issue engages a particular subset of stakeholders, but taken together, they engage all of the stakeholders in the graduate enterprise, both inside and outside the university. The four policy issues are:

- Curriculum Innovation and Reform
- Quality Assessment of the Ph.D.
- Sources and Structure of Student Funding
- Post-9/11 Policies

The key stakeholders for “reform” in graduate education are faculty, students, graduate schools and, of course, employers. In terms of Ph.D. assessment, there are three major categories of stakeholders: national organizations (the National Research Council, the Council of Graduate Schools and the National Academy of Sciences), academic administrators, and our “bankers.” The stakeholders for the funding policy issues include federal funding agencies, state policy-makers, academic administrators, and researchers and faculty. Finally, there are numerous stakeholders in post-9/11 policy-making, including federal officials (State Department, Justice, Homeland Security), academic administrators, researchers, and, of course, international students.

The Challenge of Curriculum Reform

Most academics of my generation have accepted, as an article of faith, that doctoral education in the U.S. is one of the country’s most successful enterprises, as evidenced by the more than 220,000 international graduate students enrolled in our programs and by the remarkable success of our research enterprise. Thus many faculty and academic leaders were not prepared for the findings of a series of studies conducted during the last ten years, which reported the views of more recent Ph.D.s on the quality of their graduate experience. These studies concluded that although recent Ph.D.s are satisfied with their graduate school experience overall, and although they value the research training they have received, they are distinctly less satisfied with the process and outcomes of the doctoral experience.

Specifically, current doctoral students and recent alumni want more:

1. Curriculum breadth and opportunity for interdisciplinary study
2. Information about the process and outcomes of graduate study before they start—i.e., a process with more transparency
3. Attention to the job skills required in the marketplace
4. Effective career guidance and job placement (non-academic as well as academic)

The bottom line of these studies is that for the doctoral students and new Ph.D.s surveyed, more that 50% of whom find their first jobs in the non-academic sector, the vaunted American Ph.D. did not prepare them as well as it should have for the jobs they got or for the careers they followed. And these sentiments are generally shared by their employers.

These studies have led to a proliferation of “reform” activities in graduate schools across the country. Besides local efforts, they include a number of nationally directed movements that began in 1993 with the “Preparing Future Faculty” initiative, directed out of the Council of Graduate Schools, and that continued with others like the Carnegie Initiative on the Doctorate, the Re-envisioning the Ph.D. program, the Responsive Ph.D. Project, and the Sloan Professional Science Master’s programs. We can talk about the specifics of these various reform efforts during the course of the next several days, but here I simply want to indicate that demands for reform are churning the waters in our graduate schools at both the doctoral and the master’s level, and our deans are engaging faculty, students, employers, and fellow administrators in the discussion. The policy challenge for universities is to respond creatively to these calls for reform while preserving the strength of the research enterprise to which graduate education is so closely linked.

The Challenge of Ph.D. Quality Assessment

The second policy challenge has to do with the assessment of our doctoral programs. The key question is: How effectively are we assessing the quality of doctoral education in light of the significant changes it is undergoing, in terms of both the function of the doctoral degree and the content of doctoral fields of study?

Graduate education enjoys deep support from the U.S. It has earned such confidence not only because of its tight coupling with the research enterprise, which is seen as contributing to the American economy, but also because historically it has conducted rigorous self-assessment. Once a decade for the last 40 years, a national assessment has ranked doctoral research programs based on the best knowledge available at the time. The National Research Council (NRC) is now poised to launch the next study but is encountering considerable controversy—for two reasons. First, there are new demands to incorporate “reform” criteria as metrics for quality. Second, to assess anything, the unit of analysis—here the doctoral program—needs sharp delineation of boundaries; yet the dominant curricular trend in the last decade has been the *blurring* of boundaries, as graduate training comes to mirror interdisciplinary research.

One question that the NRC will need to confront as it formulates the parameters of the 2005 assessment is: “How should the new insights from the doctoral reform movements be incorporated into the forthcoming assessment?” Stated another way, “Should actual career outcomes be used to assess the quality of our doctoral programs?” In previous assessments, the scholarly quality of the program, as evaluated by faculty peers at research-intensive universities, was assumed to be a proxy for overall doctoral program quality. But today, when nearly half of the Ph.D.s are employed outside academe and a high percentage of those working in academe are faculty in non-research intensive universities, many stakeholders are calling for a more outcomes-oriented scheme of measurement.

A second question with which the NRC has struggled relates to the unit of analysis that should be considered for purposes of quality assessment. A major impact of the explosion of interdisciplinary research and teaching over the past decade is that the boundaries of disciplines are blurring in ways that challenge those who want to compare the quality of Ph.D. programs in a specific field across all universities offering the Ph.D. in that field. Examples of these hybrid fields range from Bioinformatics to Electronic Materials Science, from Nanotechnology to Functional Genomics. Yet comparison among programs is essential if we are to continue moving the quality of graduate education forward. So while enormously enriching for student learning and for research, interdisciplinarity poses puzzles to those both inside and outside universities who must award resources through rigorous assessment-based competition.

With respect to assessment itself, the challenge is to move assessment methodology forward in a way that accommodates the changes underway in the doctoral enterprise and simultaneously facilitates rigorous assessment that engages a broad set of stakeholders, including the national organizations that both conduct and depend on the assessment (National Research Council, the National Science Foundation, the National Institutes of Health, the Department of Education, etc.), governing boards of state universities, and senior leadership in all of our institutions (presidents, provosts, graduate deans, research leaders).

The Challenge of Funding Policy

The third policy challenge facing graduate education in the U.S. is the ubiquitous challenge of funding. The challenge relates both to ensuring the appropriate level of funding for graduate students and to packaging it in a way that best supports the evolving graduate educational objectives.

As you know, there are basically three sources of support for graduate students: university sources which, in a public institution, may be enrollment-generated or appropriated directly through a state budget process, federal sources channeled through federal agencies, such as the National Science Foundation (NSF), the National Institutes of Health (NIH), the Department of Energy, the Department of Defense, and private sources dedicated to graduate education. But whatever the source, the student receives the funding in one of three forms: the teaching assistantship (typically university support based on state funding), the research assistantship (typically, though not exclusively, federal support based on traineeships or research grants to faculty), and non-service fellowships (typically from university endowments, federal agencies such as the NSF, or private organizations such as the Howard Hughes or the Jack

Kent Cooke Foundations). In science and engineering, the lion's share of support comes from federal research grants, but most students are supported by a blend of these sources and forms of support over the course of their studies.

I began by noting that challenges reside both in the level of funding and in its packaging as awards to individual students. First, regarding funding levels: The federal investment in doctoral education has been significant for decades and is the principal source of support in science and engineering fields. With the doubling of the NIH budget and a target of doubling the NSF budget, the flow of dollars into doctoral education is on the rise, pushing the NSF fellowship awards from $21,000 to $25,000 to $30,000 in three years. There is even some discussion that stipends for federally funded research assistantships will be pressured to follow the fellowships to the $30,000 level.

But at the state level, the trends are in the opposite direction. The state universities are experiencing some of the most dramatic budget cuts in decades, as states attempt to respond to their constitutional mandates to balance the state budgets. Deficits range from significant to catastrophic, with an inevitable impact on state-supported teaching and research assistantships. The participants here from Kansas, Missouri, Iowa, or Nebraska all have their own stories to tell in this regard. And this is happening at a time when demand for graduate education is up across the board, as graduate enrollment predictably moves in an inverse relationship to the economy. If these challenges concerning funding sources were not enough, at the same time serious questions are being raised about the packaging of funding for the individual student.

We know from "reform"-based research that some combinations of support are more likely to result in a good outcome for students than others and, in particular, that some are more likely to ensure that students actually complete their degrees. We also know that placing time limits on support will encourage both faculty and students to make sure the student graduates. We know that for women it is critical to have experience as a research assistant. And we know that when financial support mechanisms build participation of students into the academic life of the department or program, students are more likely to succeed.

The current policy challenge—and this engages a series of stakeholders (federal funding agencies, state officials, university administrators including graduate deans, and research faculty)—is to build as many of the insights about support packaging as possible into the requirements of federal support programs without binding research PI's in ways that damage the effectiveness of the research enterprise. The IGERT program at the National Science Foundation and GAANN program at the Department of Education illustrate efforts to meet this challenge. But the bulk of federal funding is still through the PI-supported research assistantships, where the decisions as to the process and opportunities linked to each assistantship belong exclusively to the funding Principal

Investigator (PI). Therein lies the biggest challenge, and I look forward to more discussion on this topic over the course of our retreat.

The Challenge of Post-9/11 Policy

There is no way to discuss developments in doctoral education today in the U.S. without some reference to the residual effects of 9/11. The legislation enacted in the wake of 9/11 has clarified for all observers the extraordinary dependence of some graduate fields on the constant flow of international students. Currently, international students constitute only 16% of all graduate students enrolled in American universities, but they are 50% of all doctoral recipients in engineering, 48% in computer science, 43% in mathematics and 55% in economics. U.S. graduate schools have benefited from this wonderful talent from around the world. But the implementation of the post-9/11 legislation regarding foreign nationals, which in principle enjoyed support from the entire university community represented in Washington, has resulted in implementation procedures that will inevitably slow the flow of foreign talent to our shores. And this is happening just at the time when our competitors around the world are ratcheting up their graduate training capacity. The seeming inability of the United States to develop a robust domestic talent pool for doctoral study in science and engineering is approaching a national crisis. Much of the national discussion in recent weeks about the U.S. Supreme Court decision on the constitutionality of the University of Michigan's affirmative action program is really a discussion about how America can prepare effective pathways to graduate school for historically disadvantaged groups to meet its future workforce needs. Futurists tell us that children of these families will soon constitute a majority of those graduating from high school in the U.S., and thus this is a talent pool that our country cannot afford to ignore.

The challenge to our universities is to maintain openness to young scholars from around the world and simultaneously redouble our efforts to expand graduate preparation and opportunity for historically underrepresented groups. It also means redoubling our efforts to graduate those whom we admit to our programs from all segments of American society—another topic for discussion throughout our retreat.

The Leadership Response

This morning I have shared with you four major policy challenges facing graduate education in science and engineering today. How well are we responding to these challenges? Frankly, given the diversity of universities and stakeholders engaged in the enterprise, it is difficult to say. However, I can say where the responsibility for crafting an effective response lies.

Across all the unique settings in the U.S. within which graduate education is conducted is a common structure called the "Graduate School." The Graduate

School, as you know, is the place in the research university charged with responding to and integrating the varied interests of students, faculty, and key external stakeholders to advance that particular university's graduate education mission. It is the central office charged with oversight of graduate programs and graduate students. The graduate dean brings a university-wide perspective to issues across departmental and disciplinary boundaries. Our graduate deans, who sometimes also hold the title of Vice President for Research, interpret their role in the university leadership team as less one of directing the faculty, department heads, or fellow academic administrators and more one of communicating, negotiating, inspiring and, yes, regulating—as, Janus-like, these deans seek to protect and enrich the graduate experience in light of all the challenges I have described.

Again, how well are our universities responding to the policy challenges to graduate education in science and engineering today? As the president of the Council of Graduate Schools, I am at the hub of the graduate dean community. From this vantage point I can attest to the fact that on all four challenges discussed, our graduate deans are actively engaged. But they can't do this job alone. Here in Kansas, at this gathering of administrators, key research faculty, and legislative directors, you have brought together what for the Midwest are many of the major stakeholders, and thus many of those whose reflection, input and resolve is required to craft a powerful and effective response for Midwestern universities and perhaps for the nation. I am delighted to be with you today as we begin together to take up the challenges that lie ahead.

IS ACADEMIC RESEARCH SUSTAINABLE?

Robert E. Barnhill
President
KU Center for Research

I am pleased to participate in my sixth Merrill Center summer meeting on research and graduate education policy. These meetings involve the university communities from the midwestern four-corner states of Kansas, Missouri, Iowa and Nebraska. Past keynote speakers have been Michael Crow, Luis Proenza, George Walker, Joan Lorden and Marty Apple, with Debra Stewart and Martha Crago this year.

As Debra Stewart said, graduate education is primarily funded via research, especially research grants and contracts. Thus, I shall focus on some national trends in research itself, which has the obvious application to the support of graduate education. Our two keynote speakers will focus on graduate education per se.

Debra Stewart mentioned the Roman god Janus. I will remind you about Athena, the Greek goddess of wisdom, skill and contemplation. Athena once assumed the form of Mentor, Odysseus' trusted counselor, in order to become the guardian and teacher of Odysseus' son, Telemachus. Athena's attributes of wisdom, skill and contemplation are required ingredients for research success. Mentoring, too, is essential for bringing along the next research generation.

I begin with several quotations to set the stage. Horace Walpole exhorts us to perform to the best of our ability and to help others do the same when he says:

> Men are often capable of greater things than they perform. They are sent into the world with bills of credit and seldom draw to their full extent.

Research success, at the faculty or institutional level, does not *just happen*. Participants at the AAAS Research Competitiveness Meeting in 1995 agreed on one thing: Institutional research competitiveness requires leadership at every level of the university.

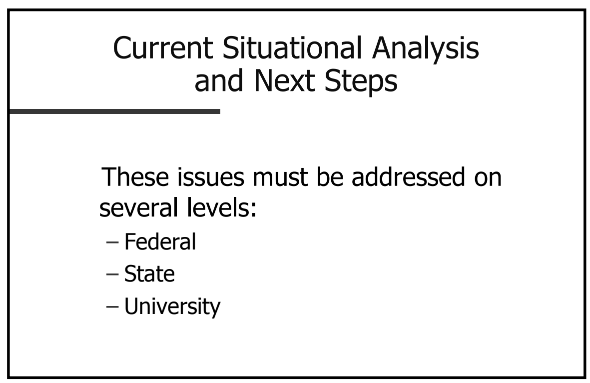
Research leadership requires the enabling, the empowerment of the faculty and students. As an illustration of empowerment, Sir George Solti once said this about the people he led:

> When you go before an orchestra, you need to have a clear idea in your mind—a sound image—of what you are trying to achieve...If

your imagination is clear, then you will communicate with the orchestra even if your beat and technique are not first-rate...I learned that they generally played below the level they were capable of achieving, and that they were happier when I made them play at their highest level. A sense of accomplishment is the best gift that any conductor can bestow on an orchestra.

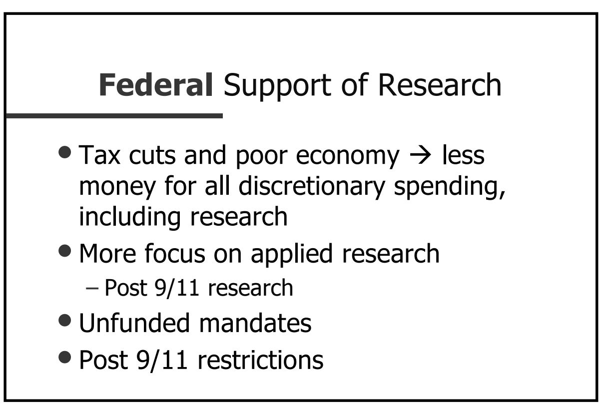
American academic research tends to percolate along in a sustaining or incremental way until some major external event occurs. Then, "disruptive" technologies, or processes, must be created. World War II and Sputnik were two such events.

Vannevar Bush made a valuable recommendation about federal support for research (found in *Science: The Endless Frontier)* and his criteria are still used today: health, wealth and defense. He also stressed producing a trained workforce and, as a co-founder of Raytheon, commercialization of university research.



It's helpful to look at the issues involved in sustaining academic research on three different levels—federal, state and university—including the current situation and, in each case, steps to take.

Federal support of research is under pressure because of tax cuts, the poor economy, and more focus on post-9/11 issues. The latter affects both the dissemination of research findings and the list of people who are allowed to work on research projects. Since 9/11, some research topics are labeled "sensitive" and findings from such projects are subject to special restrictions. Some international students are barred from working in laboratories where certain topics are studied. In addition, the federal government's highest priority seems to be the creation of unfunded mandates, so no university recovers the actual cost of federally funded research.



My recommendation at the federal level is to develop a close collaboration between the institution and your federal delegation. Among the arguments for the support of research are its value to the national interest (cf. my quote in the *Kansas City Business Journal* March 24, 2003 issue), university graduates, economic development, and the overall prestige brought to the state.

Federal Support: Steps to Take

Work closely with your state's federal delegation to support the budgets of the NSF and NIH.
- National interest
- University graduates
- Economic development in your state
- Prestige of your state

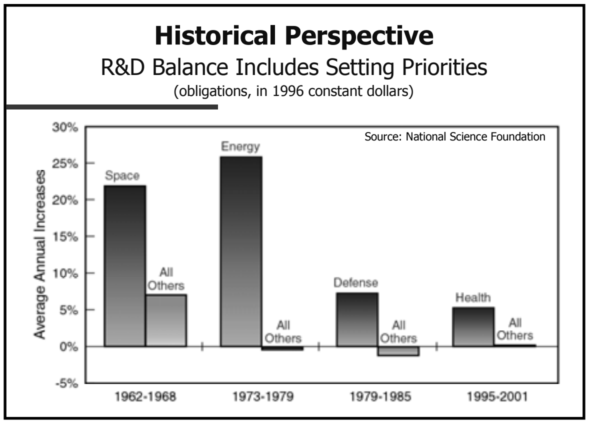
Leon Lederman, Nobel laureate, speaks highly of the social return on publicly funded research:

> Support of basic research offers a double-whammy of a solid payback to the Treasury of between 30% and 60% per year (after a waiting period of 5 and 10 years), as well as an array of new knowledge and technologies that create wealth, add to human health and longevity, and help fulfill human potential.
>
> The combination of education and research may be the most powerful capability the nation can nurture in times of stress and uncertainty.

MIT economics professor Lester Thurow cites rates of about 25% for industrial research and 66% for public research. Lederman also talks about the uniquely American synergistic combination of research and education.

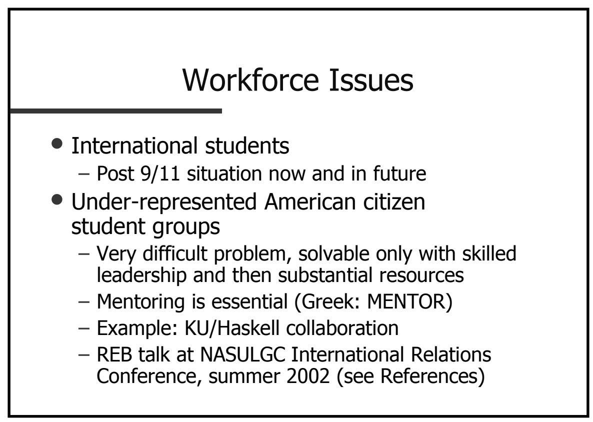
Kathie Olson, Associate Director of the OSTP, cites the Hart-Rudman Commission report on the national need to educate our citizens in mathematics, science and engineering. The commission warned that only weapons of mass destruction pose a greater threat to our national security than our inattention to investing in science and reforming curricula at all levels of our schools. Members of the commission unanimously concluded that the danger from under-investing in U.S. math and science education was greater than the danger from any conceivable conventional war. They stressed that this is important from K-12 schooling to undergraduate education, graduate and lifetime learning.

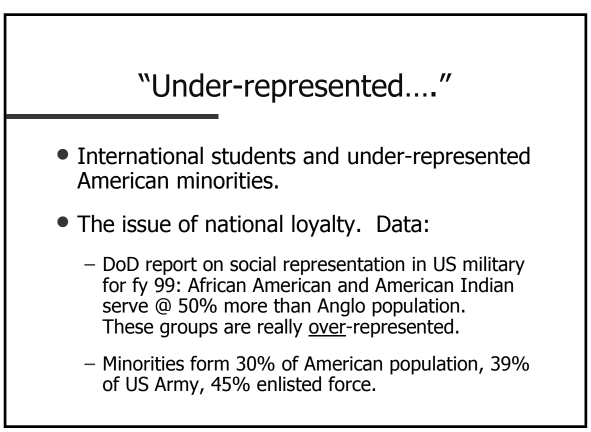
Federal support varies over time and so does what is supported. The following chart demonstrates the topics that have been of particular interest over the past 40 years: space, energy, defense and, currently, health.



Debra Stewart discussed the difficulties of international students coming to this country due to our post-9/11 rules and regulations. She also mentioned the importance of educating our own citizens. This problem is ongoing because, first, it is very difficult and, second, because it was easier to import the best students from the rest of the world.

Leadership at every level is essential to educate our own citizens. And those leaders need appropriate levels of resources. We have a good example of the extreme difficulty of such an improvement program in our KU/Haskell Indian Nations University partnership. The NIH has provided over $11 million to bring more American Indians into mathematics, science and engineering. Good will on the part of the faculty is there; over 60 faculty at the University of Kansas (KU) opened their labs to participation by American Indian students. But this is still a very difficult problem, requiring both leadership and resources.



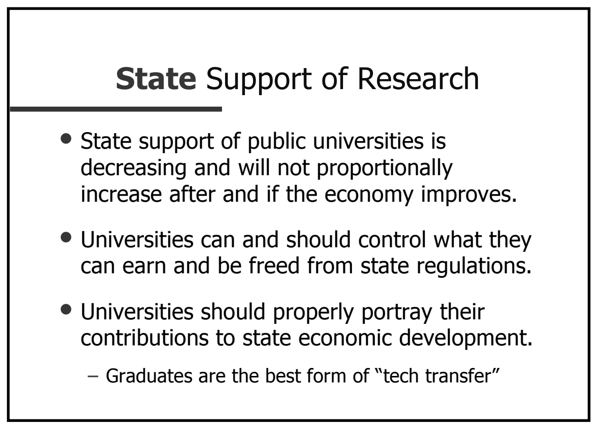


The same minorities that are under-represented in science and engineering fields are vastly over-represented in our country's military branches. A fiscal year 1999 Department of Defense report on social representation in U.S. military forces reveals that African Americans provided 20% of our active duty personnel while they make up only 14% of the civilian population; the group labeled "Others," including American Indians, were 7% and 5%, respectively. Hispanics were 11% and

15%; hence, Anglos were 62% and 66%. What more loyal pool of untapped talent could be found than those minorities, those American citizens, who are currently under-represented in our science and engineering programs?

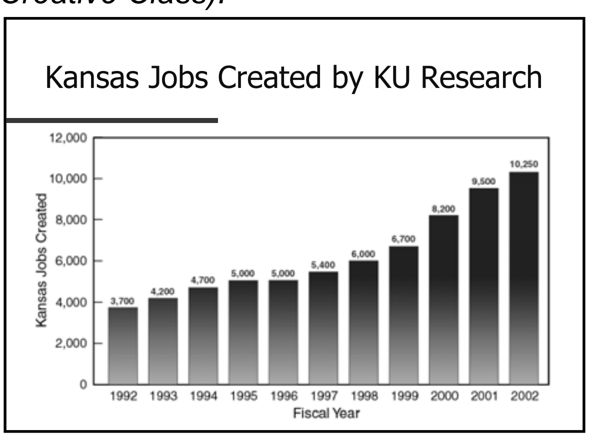
Of course, this is not a "quick fix" answer to the looming question of who will fill the ranks in our science and engineering programs, but it *is* one that every state and local school district can begin addressing immediately. Curriculum experts in our Schools of Education should collaborate with scientists and engineers, and with social scientists who understand minority cultures, to develop programmatic content and appropriate teaching techniques for our K-12 schools. Science and engineering faculty in the academy might also benefit from some teaching tips. If our minority students have a firm foundation in the sciences, along with a love for learning, they will be more likely to enter undergraduate and graduate programs in science and engineering.

I often like to quote John F. Kennedy when I say that a rising tide raises all boats. An additional positive point to improving American science and math curricula is that our majority white students will also benefit. Over time, newer educational programs will also encourage their participation in science and engineering programs.



State support of public universities is declining and will not proportionally increase after and if the economy improves. Along with this declining support should come declining control by the states.

Universities can make a good case for support in terms of state economic development. Note that the arts and humanities contribute to economic development (cf., for example, Richard Florida's recent book, *The Rise of the Creative Class).*



Using U.S. Department of Commerce indicators, the AAU estimates the number of jobs caused by the ripple effect of university research and development throughout the local economy. For Kansas, this number is approximately 42 jobs per $1 million of university R&D; thus KU's research produced over 10,000 jobs in fiscal year 2002.

Although state legislatures are not enthusiastic about supporting higher education, they do support research. Last year in Kansas, the state legislature provided bonds for university research at the same time that state budgets per se were being cut.

State Support: Steps to Take

- Targeted requests for major research facilities and personnel
  - Example: Kansas bond issue
- Economic development for
  - The state
  - The university community

Modern, big-time research occurs in interdisciplinary teams. Since these teams are difficult to arrange within departments, their development can be fostered by research centers. Regarding the former, see the article I wrote with Marigold Linton about department-focused research.

The American system combines education and research. I regard research as the education of all participants. The management of research is intertwined with academic affairs. If the local retention, promotion and tenure committee does not reward interdisciplinary research, then such a university will not do as well nationally as it could.

University Support: Steps to Take

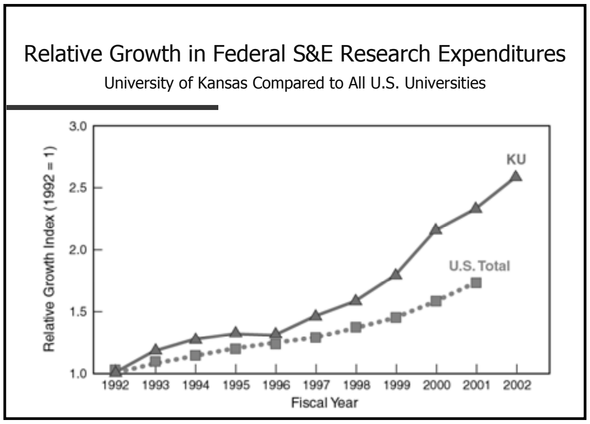
- Team-oriented, interdisciplinary research as the norm.
- How to organize?
  - Research centers, not departments
  - Research/education: a false dichotomy?
    - Implications for Academic Affairs/Research
    - The current tenure system
  - Example: KU Centers (next slides)

On the Lawrence campus of the University of Kansas, we have a vibrant research center structure. Our six "designated" centers are: The Schiefelbusch Institute for Life Span Studies, the Biodiversity Research Center, the Center for Research on Learning, the Higuchi Biosciences Center, the Hall Center for the Humanities, and the Information and Telecommunication Technology Center. Note that they cover a wide range of interdisciplinary research and education areas. The largest, the Schiefelbusch Institute for Life Span Studies, includes the Merrill Center for Advanced Studies, the host of this conference.

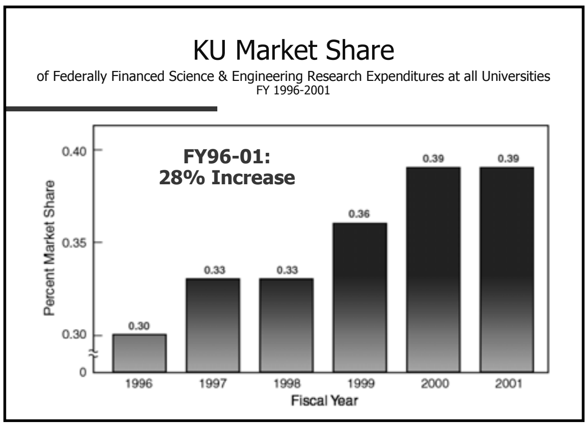
Designated Center Criteria

- Interdisciplinary research focus
- World class
  - Invited to all the right meetings
  - $5 million funding/year ($10 million as a near term target) <u>or</u> equivalent stature in field
  - Prestige (publications, presentations, etc.)
  - "You know you are in a center"
- Significant return on investment
- Ties to academic units
- Benefit to researchers

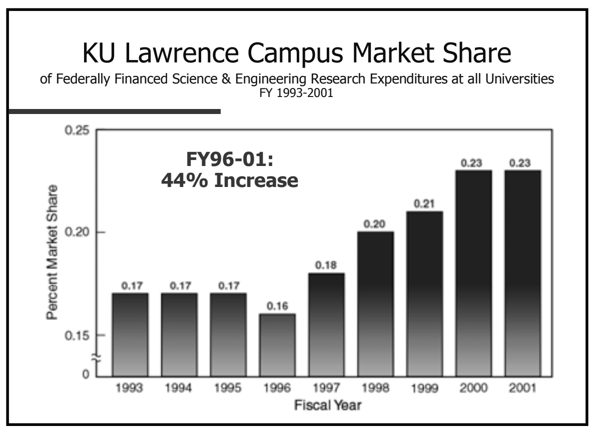
Our criteria for designated center status are listed here. They should be interdisciplinary and "world class" which means that every significant international meeting in a subject must include someone from that center. They must provide a significant "return on investment" and have ties to departments and benefits to researchers.



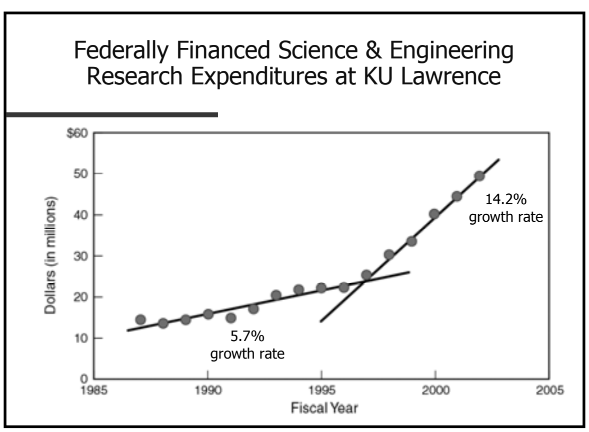
How has KU performed in research competitiveness? The gold standard for comparing research universities is federal expenditures in science and engineering. This graphic depicts how KU has improved from the arbitrary starting point of fiscal year 1992 through the latest data available. One notes that KU tracked the national trend fairly closely until about 1997 when the KU Center for Research (KUCR) was formed on the Lawrence campus; since then, KU has increasingly outstripped the national trend.



The best measure of institutional research competitiveness is market share, which is the fraction of the federal funds obtained by a given university. The average change for the system is, of course, zero. Thus KU has done well with a 28% increase over the last few years for which data are available.

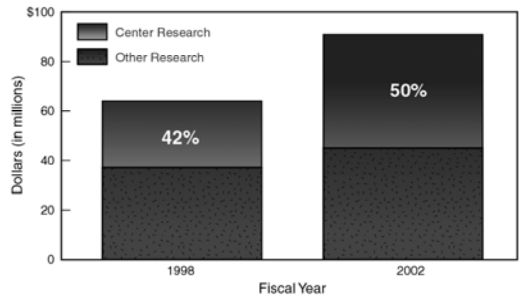


The Lawrence campus has been one of the national leaders in its increase in market share, with a 44% increase over the last few years.



Growth in federal expenditures in science and engineering on the Lawrence campus was proceeding at an average rate of under 6% from fiscal year 1987 through fiscal year 1997, when KUCR was formed. Since then, the growth rate has been about 2 ½ times as large, over 14%, and actual expenditures have doubled.

Growth of Sponsored Project Research Expenditures in Centers at KU Lawrence Campus



As the amount of research on the Lawrence campus has increased dramatically over the past few years, so, too has the proportion of research that is performed in centers. This figure has increased from 42% to 50%. Thus, centers have been extremely important in KU's institutional success.

During the past several years we have had to make some budget cuts. Adapting principles developed by our Chancellor and Provost to the research mission, we have emphasized strategic cuts and furthering the research mission. In general, the sustainability of research requires external funding, so this has been emphasized. Public service programs must be truly excellent and cost-effective to receive funding.

Budget Reduction Principles

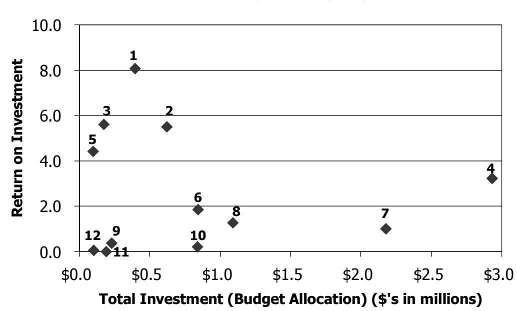
- Budget reductions will be ***strategic,*** not across the board.
- Priority will be given to programs that ***further the research mission*** measured in terms of federally funded projects and prestigious awards.

We evaluated our research centers on a number of measures, both quantitative and qualitative. In selecting criteria, we focused on measures that external reviewers use to gauge the prestige of the university. We focused on peer-reviewed research funding and on prestigious awards.

Budget Reduction Principles

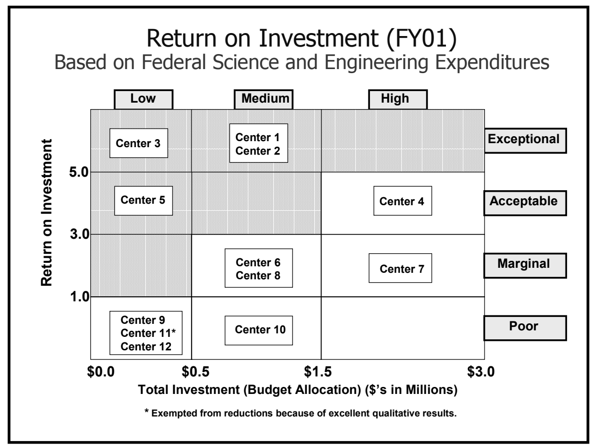
- Significant national and state ***research priorities*** will be considered and ***external grant support*** must be aggressively pursued.
- Public service programs, while important, ***must assume a lower priority*** **<u>if</u>** they are not truly excellent or require major subsidies.

Designated Centers' Returns on Investment
Federal Science and Engineering Expenditures



Return on investment in our research centers was calculated by dividing research expenditures or indirect cost return by the total center investment (budget allocation plus returned over-head). This calculation was done in two ways, by both including and excluding public service budgets. In these analyses, the overall magnitude of research expenditures, indirect cost return, and budget allocations was also considered. The number of prestigious awards, as defined by the Association of American Universities, was used as a qualitative performance measure for our humanities center. On almost all return on investment measures, the relative ranking of the research centers was the same.

A nationally agreed-upon benchmark is that the return on investment in academic research should be at least 4:1 (one internal dollar produces four external dollars). This chart is an example of research center performance using return on investment for federal science and engineering expenditures.



The return on investment data, using the criterion of federal science and engineering expenditures, locates each individual center in one of twelve sectors. Also important to us is the total investment made per center, because centers receiving considerable funds reduce our flexibility of investment. Thus, both the return on investment ratio, as well as the total dollars invested, are considered. The same methodology applies to increasing budgets as well as decreasing them.

It's also important to the missions of research and graduate education to consider and to encourage innovative thinking. Quotes from several renowned innovative individuals follow:

> Hell, there are no rules here, we're trying to accomplish something.
>
> ~ Thomas Edison

> The human mind treats a new idea the same way the body treats a strange protein; it rejects it.
>
> ~ P. B. Medwar

> The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift.
>
> ~ Albert Einstein

University resources comprise people, space and funds. We should carefully look at who makes the decisions on their allocation and what their rationale and processes are.

A verse from Proverbs, “Without vision, the people perish,” is on the walls of the chamber used by the U.S. House of Representatives Science Committee. It behooves us all to remember that without vision, research and graduate education also perish.

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UNSELLING GRADUATE SCHOOL

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Professor of Pharmacology
University of Nebraska Medical Center

Currently, there is considerable interest in recruiting graduate students into the biomedical research area and related sciences. With pressures on faculty to obtain grants and publish research findings, many faculty and administrators see graduate students as an important mechanism to increase research productivity. In such an environment, it is possible to recruit some students who do not have realistic expectations, sufficient motivation, or adequate preparation/skills. This would increase student attrition and waste resources and faculty productivity. More importantly, it is unfair to the students who were oversold on graduate school, only to find that it is not appropriate for them.

In this short paper, I propose that academic scientists and their administrators work to increase the awareness of prospective graduate students about the realities of their chosen career. Increased efforts should be directed at the recruiting of appropriately motivated and qualified graduate students. Paired with a more careful selection of graduate students there would need to be increased recruiting efforts. While most recruiting efforts are directed at junior and senior undergraduates, increased recruiting of these students only represents more intense competition for a limited pool of students. Efforts directed at educating elementary school and high school students about the opportunities and realities of research Ph.D. careers, may have greater long-range impact on training future scientists.

Prospective students should be aware of several factors:

1) Work-effort expectations. The expected work-effort necessary to complete graduate training in normal time is very difficult to quantify, but the time input is generally considered to be well above 40 hours/week. Perhaps 60, perhaps 80. This number is further obscured by the fact that graduate work is sometimes associated with long, unproductive hours. At a minimum, students should enter programs knowing faculty expectations. Apart from the question of the effort that is necessary to accomplish the Ph.D., is the separate question of how much effort is necessary to generate the credentials to be competitive for jobs of the type the student is seeking. The necessary credentials will be different for different jobs.

2) Doctoral training duration. In the biomedical research field, the average years of graduate training to reach the Ph.D. is nearing 7 years (6.9 years in 1995, up from 5.7 years in the 1970s)[1]. At my institution (UNMC), the

time to Ph.D. is approximately 5 years, presumably reflecting the predominance of research assistantships over teaching assistantships.

3) Job market. While the unstated goal at many institutions appears to be to prepare students to fill academic positions supervising biomedical research laboratories, the reality is that most students do not reach this goal. This leads to the question if students are aware of the different job markets for biomedical Ph.D.s and if students have accurate expectations. As surveyed in 1997, 40% of recent Ph.D.s reported entering employment that differed from their initial objectives upon starting graduate school[2]. Students should probably also learn just how competitive are the different job positions. Presumably, this would screen for the appropriately motivated (and unrealistic) students and may give some students further motivation to achieve. In either case, it may be helpful for graduate student recruiters to know and to provide student-outcomes information.

   Currently about 50-55% of biomedical research Ph.D.s find a position in academia[1] and many of these positions are teaching without significant research. About 30% of Ph.D.s find jobs in industry, and the remaining occupy a variety of related niches in government (10%) and other areas[1]. Overall, unemployment is very low (1%), and underemployment, or involuntarily out of field, has been estimated to be about 3%. While there is significant competition for many individual faculty jobs, positions have been available for the Ph.D.s generated. Estimates for the future job market is generally positive but closely tied to economic recovery and growth[3]. Other student-outcome information is available at: www.phd-survey.org/related_sites.htm

4) Job preparation. Given that many of the future jobs for biomedical Ph.D.s are non-academic and/or non-research, are students being prepared for the jobs they are likely to seek? What training prepares them for job activities such as grant writing, teaching preparation, lecture skills, industry research, budget management, administration, personnel management, and student mentoring? We appear to largely assume (correctly?) that if one can do research, one can do anything else. Internship programs can help close these gaps as well as "survival skills" workshops and outside speakers from nonacademic professions.

5) Postdoctoral training process. Many incoming graduate students have little awareness of postdoctoral training. This is becoming more relevant since the average duration of postdoctoral training has been increasing. In 1981, 24% of individuals 4 years after being awarded their Ph.D. were still postdoctoral fellows. This number increased to 32% by 1995. Still, by 1995, biomedical Ph.D.s, most (about 2/3rd) had a satisfactory potentially permanent job by their 4th year after receiving their Ph.D. degree[1]. Furthermore, since the NIH 1st year postdoctoral fellowships will soon be

at $45,000/year, being a postdoctoral fellow is not necessarily a hardship. Nevertheless, for a student to go through roughly 11 years of predoctoral and postdoctoral training, they should be aware of this process and they had better enjoy the process.

6) Value of School Name Recognition? In recruiting graduate students to a school of minimal name recognition, students should ask if getting into a more prestigious school would increase their career potential. While it may be self-serving (and minimally researched), I suggest that school name probably does not meaningfully affect outcome. In one study of students entering college, students who were accepted to Harvard, but went elsewhere, did as well as those who went to Harvard[4]. Bright, motivated students do well. At the research graduate student level, the quality of training is more closely related to the quality of individual mentorship rather than the overall quality of multiple departments, thus the identity of the institution is less relevant than the identity of the mentor. And, in turn, the identity of the student is more critical than the identity of the mentor. This conclusion is consistent with NIH findings that students who went to non-NIH training institutions were only about 20% less likely to obtain an NIH or NSF grant 7 years after receiving their doctorate[5]. A greater advantage is seen for students who received individual predoctoral training grants compared to students at NIH-training institutions. An evaluation of publications and citation rate at NIH-training and non-NIH-training institutions yields similar results. Given that bright, motivated students do well, the limited disparity between non-NIH and NIH training institutions speaks well to the recruiting at non-NIH training institutions.

It is hoped that by better informing incoming graduate students about the realities of graduate school and the Ph.D. job market, students with unrealistic ideas or limited motivation would choose other careers. By taking just those students who are appropriately motivated and capable, Ph.D. programs would suffer less attrition, and both students and faculty would waste less time. (However, it could be argued that a couple years in a Ph.D. training program are worthwhile to the student even if the student drops-out. In addition, some students may mature into the role successfully). With a limited pool of graduate student applicants, such a truth-in-advertising campaign may even further reduce graduate student applicants. Thus, to offset this potential decrease, it may be helpful to increase the pipeline of interested students. From talking with many students, it appears that there is a huge potential student pool, but that these students have no idea as to the nature of graduate studies. I have known students who have graduated in biology, have had many classes from Ph.D.s and many laboratory sessions with graduate student teaching assistants, and yet, the students have never entertained the idea of getting a Ph.D. and they frequently have little idea as to what it would involve (other than being a T.A.). Direction on the career path to medical doctor is apparently a birthright; yet, we have failed to educate our undergraduate students (and younger) about careers involving Ph.D. training. I suggest that if we in academics can better inform students of all ages about the nature of our business, there would be a stronger applicant pool. By making sure that these recruits have accurate and realistic expectations, as well as sufficient motivation and talents, academics could be further strengthened.

Conclusions

Inform students early about the facts and best estimates regarding graduate school training and Ph.D. careers. Select highly motivated, talented students who enjoy the process of research discovery.

End Notes

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WHY INTERDISCIPLINARY GRADUATE PROGRAM ATTRACT GREAT STUDENTS

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There is broad recognition among the life science disciplines that "inter-disciplinary" programs are successful. This success has led to a huge growth in the number of interdisciplinary graduate programs in biosciences in the past two decades. At Iowa State University there are now nine such majors available for students interested in life sciences, ranging from Genetics to Water Resources. There is an increasing trend to bundle these programs administratively into larger umbrella "Bioscience" programs that recruit students broadly, provide a common set of foundational didactic courses, then allow the students to select a personalized program of courses and thesis research that may be interdisciplinary or more traditionally based in a department.

The term "inter-disciplinary" is widely used to describe programs that provide graduate training that crosses traditional disciplinary boundaries, such as molecular, cellular and developmental biology. Programs such as these might more appropriately be called "multi-disciplinary" so as not to be construed as offering education in a new, melded area that might emerge between fields. Inter-disciplinary is also used somewhat interchangeably with "inter-departmental," because when crossing disciplinary boundaries, one frequently also crosses departmental boundaries. A program will of course be inter-departmental when there is no standing department that addresses the training area. This is true, for example, for the Graduate Major in Toxicology at Iowa State, which has no department of Toxicology. However, some training programs emphasize an area that is dominated by a single department, so the "inter-departmental" term is not universally applicable.

What makes interdisciplinary programs attractive to students that might otherwise join departmental programs, and especially, to high caliber students? There appear to be four primary enticements that interdisciplinary programs can use to their advantage.

First, there is widespread public perception that the leading edge of science crosses old boundaries. This may derive fortuitously from the various science-based programs on public television. High school students, undergraduates, and their teachers have gained an idea of what molecular biology is from shows that reveal with great drama how it can be utilized to solve forensic mysteries or generate transgenic mice that grow twice as big as normal. This attitude is displayed proudly on the web site for The Division of Biology and Biomedical Sciences at Washington University at St. Louis, which advertises:

“The Division of Biology and Biomedical Sciences at Washington University in St. Louis originated in 1973 as one of the 1st interdisciplinary graduate programs in the nation. This interdisciplinary approach is key to solving emerging biological and biomedical problems in the ‘post-genomic’ era.” The popularity and perceived importance of such collaborative research has fueled an increase in enrollments in these interdisciplinary majors. At Iowa State, enrollment in these majors has increased from 250 in 1996 to 340 in 2001, an increase of more than one-third.

There is also growing interest in interdisciplinary research among faculty in academe, because the lines between “traditional” fields such as biochemistry and cell biology are increasingly blurred. Funding sources such as the National Institutes of Health and the National Science Foundation have furthered this blurring by offering support for research that is explicitly “cross-cutting” or “bridging between disciplines.” This prominence of collaborative research is often reflected in the reorganization, or at least re-naming, of departments at universities, to publicly demonstrate their changing emphases, and announce that they, too, are at the fore-front.

Second, there are both concrete data and word-of-mouth stories of success showing that students in interdisciplinary programs really are great. The average GRE scores for students in 10 interdisciplinary programs at Iowa State are higher than the average for the 10 most closely aligned departmental programs. The caliber of student that is attracted to interdisciplinary programs, by this one limited measure, is demonstrably superior. Faculty members of interdisciplinary programs join primarily because membership gives them access to excellent students.

Third, interdisciplinary programs can include an enticing menu of courses in their curriculum. These courses take advantage of the breadth of expertise of the program’s faculty, and also of the courses offered in the various participating departments. Because programs often involve more than a dozen departments, the list of possible courses is far larger than an individual department can advertise.

Fourth, and most important, great students are eager to explore several areas of research. They will often have had research experience through summer internships and be eager for an opportunity to do more. Thus smart applicants look for a wide choice of faculty doing exciting research. Here again, interdisciplinary programs have a clear strength. With a single focus on graduate education, programs can include far more faculty than could be accommodated in a departmental setting. The freedom and choices for a thesis research area that an interdisciplinary program can provide are almost overwhelming.

What are the challenges for making interdisciplinary programs a strong tool for recruiting and training excellent graduate students? There are three components that contribute to vitality of a graduate program in any setting, but perhaps most clearly in the interdisciplinary venue: faculty time and commitment, faculty collegiality and common goals, and not surprisingly, money.

Time is perhaps the most crucial challenge for an interdisciplinary program. Programs are motivated by a group of faculty that are not in a single department, and who must therefore also maintain their widely varying departmental responsibilities while contributing time and energy to (often several) interdisciplinary majors. Directors or Chairs of these programs, and certainly members of the necessary program committees, volunteer with the realization that this effort will go largely unrecognized outside of one line on an annual activity report. Enthusiasm and energy are not limitless resources, and wane as the priorities of grant writing, publication and department service supersede. This is a challenge that is correctable, particularly at the departmental administrative level. Departments must recognize and give value for the commitments of their faculty members to the interdisciplinary programs that provide their faculty with high-quality students. Teaching release for program directors is crucial. While grant writing slows, it is especially helpful to give additional support through research assistantships.

A more difficult challenge is the need for program faculty in multiple departments and the departmental members that are <u>not</u> in the program to agree on common goals. This ranges from collegial arrangements and attendance at seminars of the interdisciplinary program to the sometimes tumultuous bargaining that accompanies faculty hiring. This challenge arises precisely because interdisciplinary program curricula cross many departmental boundaries and require faculty that will be hired and assigned through multiple departments. Departments must claim and support these boundaries in their own missions, or there may never be a way to provide the research and teaching expertise that the interdisciplinary program needs. Interdisciplinary programs need faculty members that give voice to the program's needs to develop departmental advocacy in hiring decisions, and security in continued curricular support. Equally, departments and their Chairs need to listen.

The final challenge is, not surprisingly, money. In certain instances, departments may have no graduate recruitment or training program of their own. Other departments may derive substantial numbers of students through these programs. Overall, at Iowa State, the enrollment trends for interdisciplinary programs indicate that over one-third of all graduate students will soon be recruited through interdisciplinary programs. Despite this, interdisciplinary programs are often not part of the regular budgeting process that focuses on undergraduate education and is administered through departmental and college channels. This can result in faculty efforts given, benefits produced, but no funds to carry the increasing load. Volunteerism and collegiality can only go so far. Diverting at least a modest sum for the important job of attracting excellent graduate students should become part of departmental, college, and university thinking.

In addition, it is common that when students in interdisciplinary programs join a laboratory for their thesis research, they become an administrative responsibility of the “home” department of their major professor. When a department has its own recruitment and training program for its own majors, the question of equality arises. Interdisciplinary students cannot be “last on the list” when teaching assistantships or emergency funding are allocated.

Finally, if interdisciplinary programs represent and can advertise their cutting-edge, attractive training, how do the great students choose which to join? Competitive stipends are needed, to be sure. Few programs can take the risk that their reputation is outstanding enough that a student will choose to study with them for $15,000 when they might make $20,000 (or more) elsewhere. And tuition waivers or payments can add (or subtract) substantially. But within a cohort of institutions providing similar overall funding, good students are immensely influenced by the reputation of the university for making research discoveries. There are no known instances of recruitment based on exciting committees. To students, legislators, journalists, and the general public, the way a university is recognized and remembered is through its research—the insights, the inventions. Research discoveries drive the reputation of universities. In the 1993 NRC survey of Ph.D.-granting programs, faculty publications and citations are one of the few parameters that distinguish one university from another. But research discoveries are not made by faculty directly, and good students know that they will be the first ones that actually get to see that discovery. University administrators need to understand that funding the graduate students and post-doctoral fellows that produce the news-breaking research gives great pay-offs publicly, especially in a time when tuition increases and budget cuts are making headlines. Discoveries in the leading edge of interdisciplinary research require great students with interdisciplinary training, and changes in old ways of investing in graduate education.

EFFICIENCY IN DOCTORAL TRAINING

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Introduction

Like most faculty at research institutions, I am a scientist with an active research program, with current projects funded by NIH, NSF, and industry. I am also an educator engaged particularly in graduate training, and I am currently enjoying a role as advisor/mentor to an excellent collection of five doctoral students and a postdoctoral fellow. However, I am also an administrator in both the research (chair of the Lawrence campus IRB), and the academic (associate dean of The Graduate School) domains. Given this breadth of duties, I am privy to multiple perspectives within the academy about many of the things that the academy does. Most notably with regard to this conference, I am acquainted with a number of views on graduate education, and my comments concern this topic.

Most faculty members (including myself) believe that graduate education —and quite especially doctoral education—is central to the mission of the research university. Among the primary functions of the public research university is the generation of new, non-proprietary knowledge and the sustenance of the public intellectual endeavor. The former charge is readily measured by institutions' output of research and scholarly products. Defining success at the latter is a little more difficult to articulate, but I would propose that this is best operationalized by the training and production of new researchers and scholars. Seeking excellence in these two goals is a highly reciprocal and transactional process; an institution hiring nationally visible and well-funded researchers will (often quickly) gain in its research reputation. This, in turn, will start to attract good graduate students. The presence of good graduate students will make that institution attractive to other desirable faculty candidates, and so on. This cycle is represented in Figure 1. It should be noted that the cycle could run in any causal direction, as indicated by the bi-directional arrows in the figure.

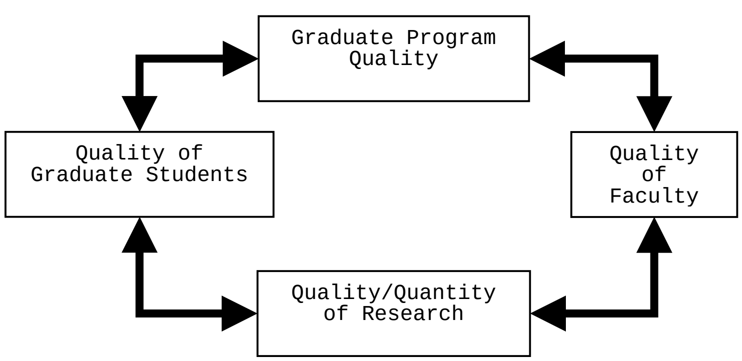

Figure 1. Interplay of research and graduate education

An Efficiency Analysis of Doctoral Training

In our discussions of replenishing the professoriate and training the next generation of researchers, there are philosophical and emotional arguments to be made for the pre-eminence of doctoral education as the *sine qua non* of the research university. However, these are complicated times and with research universities rethinking their priorities, nothing is sacred; all of the functions of the research university must be conceptualized and/or optimized for the greater good of the institution (an academic euphemism for what is more colloquially called "the bottom line"). Given this shift in the paradigm, I wish here to sound a (proactive) alarm for traditional doctoral education. I fear that traditional doctoral education is at risk in these times—yes, even within the modern research university. My judgment of this risk is based largely on the inescapable perception that doctoral training is, in a word, "inefficient."[1] I will suggest some strategies to increase efficiency in doctoral education that do not involve increased resources or funding. Throughout, I will also argue that the adoption of these strategies will contribute to the research mission of the institution and produce graduates who will be highly competitive for the academic and nonacademic marketplaces of the 21st century.

Table 1. Head-to-head comparison of graduate training programs: A "bottom-line" view

Program Variable:	**Doctoral**	**Master's**
Scope of Student Recruitment	national	local/regional
Faculty Prominence	national	unnecessary
Program Structure	less	more
Institutional Resource Use	more	less
Cohort/Program Size	smaller	larger
Faculty/Advisor Investment	higher	lower
Student Investment	higher	lower
Tuition/SCH Generated	less	more
"Bottom-Line Efficiency"	low	high

Competition in the Age of Efficiency: A Comparison of Doctoral and Master's Programs

Those of us who engage in doctoral training often consider it to be the only kind of graduate education worth doing in higher education. In truth, however, there are really two kinds of graduate education, and the "other" kind is quickly gaining ground in the academic domain—and for good reason. I refer here to the professional or terminal Master's degree program: the professional MBA, MEd, or MSW, or the stand-alone MA degree that prepares students for a clinical profession. Table 1 shows a head-to-head comparison between

[1] I use the term "efficiency" here in its classic and generic form; that is, the ratio of resource use (in terms of time, effort, material resource, etc.) to output (doctoral graduates produced).

traditional doctoral education and these master's programs from the bottom-line/efficiency point of view. Doctoral education loses quite handily on all counts where one compares resource use to output. The point of this, of course, is not to suggest that we create more of these Master's programs. Rather, I seek to show those of us who engage in doctoral education that, from the administrative point of view, a reasonable case can be made that "business as usual" with regard to this type of training may not be particularly good business after all. In this spirit, I suggest that some proactive steps might be worth considering.

Critics of this analysis will complain that doctoral education is necessarily costly in resources and time because it involves training to extraordinarily high levels of rigor and quality. At best, this is a difficult empirical point to prove, and at worst it belies a reluctance to examine the situation critically. It is worth considering the possibility that the things that make doctoral education inefficient may have little to do with the actual quality of doctoral graduates, and that increasing efficiency will actually improve the research productivity and marketability for our graduates.

Attrition and Time to Degree as Indices of Efficiency

How does one improve the efficiency of doctoral education? Table 1 above is instructive but, in truth, doctoral training cannot be made to conform to the parameters of master's programs. For example, doctoral training will never represent more than a small blip in credit-hour production and tuition revenue, compared to undergraduate and master's programs. However, I propose that by addressing two related and fundamental problems at the heart of inefficiency in doctoral training—attrition and time to degree—we may see major improvements in overall efficiency and increases in research productivity of both students and faculty.

Attrition. We accept students into graduate programs but the data suggest that many (if not most) drop out of those programs before finishing the terminal degree. This attrition varies somewhat by discipline and institution, but the best nationwide figures I have seen estimate it at about 40% to 50%. Interestingly, my experience is that many faculty are incredulous when presented with these figures; they estimate attrition to be, at most, 10%. Attrition, of course, represents inefficiency of time and effort on the part of both students and advisors. Students drop out of doctoral programs for various reasons but two reasons in particular stand out in my mind as primary causes. First, students realize that they do not want to engage in the work required for the doctorate. Second, students change their minds and decide that they no longer want to follow the career path for which the doctorate had been necessary or desired.

Time to Degree. Aside from those students who drop out, those students who do complete the doctorate are taking longer to finish their degrees. This also varies by discipline and how one chooses to measure it, but the best estimates we have place average time to degree somewhere around 7 to 10 years. Ideally, the doctorate should take four to six years to complete; the extra years needed to complete the doctorate obviously represent inefficiency of time and effort in producing new researchers and scholars. The increase in this variable over the last two decades has been often attributed to lack of graduate funding (e.g., fellowships, assistantships), which may cause the student to take on other forms of employment while earning the degree. There is some evidence to support this, but it is also clear that financial constraints are not the only ones to consider.

Improving Efficiency

Given these arguments, the obvious steps to take involve (a) attenuating attrition by either reducing it or (more realistically) have students who are going to drop out do it sooner and with a tangible product, and (b) reducing time to degree. In each case, we are looking to facilitate the movement of students through doctoral programs in a timely fashion.

Some think that improved selection/admissions processes would address problems of high attrition and long time to degree. Theoretically, the argument goes that if we were more selective in who gets admitted to doctoral programs, all those admitted would finish the doctorate (and quickly, at that). I believe this idea is wrong on two levels. First, it's wrong philosophically—it would be counterproductive if we are looking to replenish the professoriate or augment the pool of available researchers for the next century. If anything, we should be looking to be more inclusive under these conditions, not less. Second, it's mistaken practically. Can we really predict who will finish a doctorate (quickly) at the point of application from the information provided in the application? As a developmentalist who has tried to predict later outcomes from earlier characteristics, I'm highly skeptical of this.

Instead, I suggest that what we can and should do is improve our chances by improving our administration and advising. Below are some suggestions that seek to do just that. They are grouped by the institutional level at which they might be implemented.

Administrators

Set—and enforce—reasonable time limits. All research universities have time limits to the completion of the degree. In my experience, these limits can and often are successfully petitioned and extended. Such extension usually comes with the support of the advisor and often with the support of the program. The regular granting of extensions sends an obvious message to students and faculty that the time limits need not be respected, or that they are arbitrary. The enforcement of these limits by administrative units above the department or program would establish a culture change with regard to time to degree. It is most effective for such enforcement to come from above the program level, so that advisors avoid the inherent conflicts of interest in serving as both advocate and regulator for their students.

Establish a probationary period for pursuit of the Ph.D. This may be done at the school/college, department, or program level. It can be made clear to students that even though they have been admitted to a Ph.D. program, admission *per se* is not a guarantee of entitlement toward the degree. Students can be advised that the period leading to, for example, the MA degree (or some equivalent point at the beginning of the doctoral program) is considered to be a "probationary" period. At the end of this period the student's advisor and/or the student's committee will engage in a discussion of the student's progress in the discipline and program, from which a formal recommendation can be made as to whether the student should continue on for the doctorate. This gives programs and students an institutionalized and face-saving "out" for both student and institution (particularly if the period ends with the M.A., where the student will still walk away with a graduate degree) in cases where the student chooses not to continue the work toward the doctorate.

Develop graduate curricula that are both structured and flexible. The doctoral programs with which I have become familiar (either as a faculty member or as an associate dean) are bimodal with respect to coursework requirements. Some are completely unstructured (e.g., 3 required courses), while others have a required coursework load that is particularly burdensome (e.g., 17 required courses). The rationale for the former is that it allows for optimum flexibility. At best, the latter is justified based on the expectation that students will be both broadly and deeply trained[2]; at worst, it serves to populate graduate seminars adequately in the face of university class-size minima.

In programs with little structure, students take too long because they flounder about in their studies (not to mention that faculty in the program cannot expect a reasonable amount of core knowledge in the students enrolled in their graduate seminars). In programs with too much structure, the coursework gets in the way of the development and conduct of the research program that will make the student competitive in the academic marketplace, and often extends time to degree.

It has long been my opinion that required curricula in doctoral programs should be designed for completion by the end of the second year. To me, this translates to no more than 8 required courses, with just electives (chosen by the student as s/he sees fit) remaining beyond this point. This allows enough structure to support students' acclimation to the academic environment at the start of their graduate careers, and then enough time to develop a thoughtful and meaningful research program (and presumably, thoughtful and meaningful

[2] Perhaps this is why inter/multidisciplinary programs disproportionately fall into the latter category.

research products, including grant proposals) toward the end of their graduate careers.

Balance doctoral degree requirements between traditional form and current function. A suggestion related to the one described above is a proposal to "scale-down" the traditional, formalized, and somewhat onerous format of degree products. In psychology, for example, the average manuscript length for a typical published empirical report is between 30 and 40 pages, but some theses and dissertations are 200 to 300 pages long. Is the production of a document that is five to ten times the length of the functional output of a research endeavor truly necessary? I wonder whether a student's mastery of the skills of scholarship might be demonstrated in a briefer and more functional format. I am not advocating for 9-page dissertations here, but I am proposing a more moderate length; I'd think that we all would have a sense of what that would be within our own fields. In my own discipline of psychology, this might need be only 50-60 pages.

Advisors

Make background, expectations, and requirements explicit. In the mid-1990s, I took a month during the summer and developed a handbook for my incoming and continuing graduate students that lays out the rationale for our research program at its most fundamental level, our funding sources, our facilities and sites, my expectations for program requirements and time to degree, as well as general lab policies regarding use/ownership of data, equipment, and facilities. The handbook finishes with a listing of all published research and presentations from the laboratory, showing that student authorship was more a rule than an exception on our products, and that there was a strong expectation for students to generate such products. I take some time to update it each summer; this takes a few hours at most. The handbook, which is given to each student upon their acceptance into my laboratory, establishes a culture of productivity, makes responsibilities and duties clear to all, and defuses potential problems with regard to policy. The point is that the provision of this information works, and I encourage my colleagues to develop something like this as well. Indeed, this kind of step constituted a fundamental recommendation from the 2000 National Studies on Doctoral Education.[3]

Integrate new students into existing lines of research. Many of the advisors I know insist that student projects at both the master's and doctoral level reflect contributions to the discipline that are completely independent of their own. I agree wholeheartedly that this is a goal for the end of the doctoral training sequence. However, I find that the entering doctoral student, however capable and intelligent, cannot readily or promptly conceptualize, design, implement, carry out, and disseminate a meaningful project within the context of a discipline. As such, I work very closely with students on their first research projects (usually

[3] See *www.grad.washington.edu/envision/project_resources/national_recommend.html.*

those used for the completion of the MA degree). In their first years, I will suggest that they take on a programmatic extension of my own of work. If the student so chooses to take responsibility for such an extension (most do, and are usually quite happy to do so), they waste no time floundering for a topic, and they quickly begin working on a piece of research that has a relatively high probability of providing a real research credential. In doing this, the student gains experience conducting, analyzing, and writing up the research; all of this will serve them well as they learn more about the field and then seek a more independent contribution later in their graduate career.

Give graduate students a sense of "belonging"—to the lab, to the institution, and to the field. Research on graduate education has repeatedly shown that greater integration of students into a social structure related to their scholarly work reduces both attrition and time to degree.[4] There is much that advisors can do to create and/or structure positive social supports within their research units. For example, a hierarchical laboratory structure makes clear each student's role in the laboratory, as well as the means to ascending the hierarchy in the not-too-distant future. Regular social events (even if they are infrequent), whether it is a holiday dinner or an occasional after-hours off-campus lab meeting will also serve to strengthen the social bonds among lab members. In addition, advisors can also do many things to integrate their students into the discipline at large. Major steps in this regard include introducing them to other scholars in the field, and sponsoring/advocating for their work at conference meetings. However, given the sophisticated word processing features available these days, I generate my own laboratory letterhead to use for disciplinary correspondence; listing the names of my graduate student team (in order of seniority) on the letterhead provides a sense (and perhaps some subliminal name recognition) of being part of the field on the national/international level.

Emphasize the timely generation of research products. We may not be particularly good at predicting success in doctoral programs, but we can often discriminate those students who will make good academicians from those who will not. Students who take inordinately long to finish their degrees generally are not good bets to be major contributors to their disciplines. The doctoral students with whom we are concerned here will get and keep an academic position based largely on their ability to generate high-quality research products in a very timely fashion.[5] Therefore, it makes no sense for advisors to encourage anything but

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[4] Perhaps this is in part why both indices are so high in the humanities, relative to other fields. It may be that the isolated nature of research in many of the humanities makes it difficult for students to complete or stay with their work. This implies that the creation of improved social networks in these fields would improve time to degree and attrition indices in such disciplines.

[5] I realize that not all doctoral students will seek academic posts, and that not all academic posts will require a high research output for promotion and tenure. The focus of this conference, however, is on replenishing the professoriate and how to train the next generation of researchers. In that spirit, we are speaking here of academic positions with relatively high research expectations. At this time, it is worth noting that such expectations are not uncommon at comprehensive/regional universities.

this particular work ethic in their laboratories. If this is done, it is my experience that the student quite clearly sees a path to the doctorate and beyond, and develops a sense of confidence and expectation of success. Students, of course, often cannot churn out such products (especially during the early parts of their graduate tenure) without the help of their advisors, and so the adoption of this stance within one's laboratory necessarily comes with a cost—the reading, editing, re-reading, and re-editing of (sometimes many) publication drafts and grant proposals. It should be noted, however, that such products have a tremendous up side; in the long run, they will make the laboratory, the program, and the institution more productive in its research mission.

A Personal Record of Graduate Advising

So, how do these processes work? To help elucidate this point, I refer you to Table 2, which presents my personal record of doctoral advising over the course of 15 years. I present this not as a shining example of graduate success, but rather as a concrete example of some of the issues I've discussed above with regard to doctoral education. The table shows the years that the student s matriculated in the Ph.D. program (although because I inherited some of these students from other advisors or co-advised them, not all those years represent my tutelage), their fate with regard to the degree, and their last known placement in the workforce.

The first question one has to ask is whether this is a good or adequate record for 15 years of work. If you count, I have seen only 11 students through to some level of completion to this point (although I currently have 5 more on the way). Of the 11, only 5 completed their doctorates (so the 50% statistic clearly applies to me). Of the 5, 3 have been placed in true research universities, and 2 in traditional assistant-professor roles. If the goal of doctoral training is that all students should finish, and that all should be placed in nationally prominent or visible positions, then this record is not very good.

At the same time, several things are noteworthy about this list of individuals, owing to policies that I have developed over the years that are concordant with the suggestions made in the sections above. None have left the program after becoming a doctoral candidate (i.e., ABD). The median time to degree for those who finished is 6 years, which is less than the national average for psychology. (Still, some did not finish as quickly as either of us would have liked.) For those who did not complete the doctorate, only one walked away from graduate study without a degree; those who finished M.A.s did so within a minimal period (2-3 years). Finally, those students who left the pursuit of the doctorate generally did so for multiple reasons unrelated to their satisfaction with doctoral training or lack of funding; although these may be failures from the viewpoint of my discipline, they have generally found success elsewhere for which (most of them will tell you) their interrupted doctoral training had prepared them to some degree.

Table 2. A personal record of doctoral advising

	TTD*	***Outcome***	***Placement***
A	8 yrs	PhD	Professor, comprehensive university
B	3 yrs	no degree[a]	Career in telecommunications for disabled
C	6 yrs	PhD	Associate professor, comprehensive university
D	3 yrs	left after MA[a,b]	Account analyst, telecommunications
E	5 yrs	PhD	Associate professor, R1 university
F	2 yrs	left after MA[b]	Owner, successful daycare center
G	2 yrs	left after MA[b]	Database manager, social services agency
H	5 yrs	PhD	Associate professor and chair, R1 university
I	7 yrs	PhD	Research associate, R1 university
J	2 yrs	left after MA[b]	Personnel manager, telecommunications
K	2 yrs	left after MA[b,c]	Obtained PhD in a related program

**TTD=time to degree.*

Reasons for leaving: [a]offered high-paying position in industry, [b]changed mind about academic/research career, [c]wanted doctorate in a clinical field

Summary

Doctoral training at the research university is an inefficient process. Despite its apparent centrality to the functions of the research university, its inefficiency makes it a vulnerable target in the contexts of the current economy and institutional mind-sets that feature bottom-line thinking. It will not be possible to entirely change the inefficient nature of doctoral training but it should be possible, at least to some extent, to meet the demands of the changing university environment halfway. And if, in meeting these demands halfway, it is possible to increase research productivity and reputation (and theoretically the direct and indirect grant funds that are virtual byproducts of such an increase), then the "bottom-line" issue is readily addressed as well. Many faculty will claim that the answer to all problems in graduate training lies with increased funding; in my view, funding has a considerable weight in the doctoral training equation, but it is by no means the sole term in the equation.

The apparently high levels of attrition within doctoral education may not be reducible, but it seems likely that such attrition can be recast by placing some emphasis on reducing the time to attrition (i.e., ensuring that if students drop out, they do so after minimal investment) and on documenting that the placements of students who do drop out can be at least in part attributed to the skills they acquired during their interrupted doctoral training.

It also seems quite likely that time to degree can be reduced in a number of ways that will also enhance the research mission of the institution. What I have outlined above is a combination of structuring the experience of doctoral students in terms of coursework, research, and laboratory social structure, and creating a culture of generating timely research products. If these suggestions work, all of the stakeholders in doctoral education (students, advisors, institutions, and disciplines) stand to profit handsomely.

Acknowledgements

A number of scholars and administrators (too many to name) contributed to the development of thought represented here, but I am especially grateful to Patricia Hawley, Todd Little, and Janet Frick for their comments on an earlier draft of this manuscript.

RECRUITING AND TRAINING FUTURE SCIENTISTS:

CONVERTING INTELLECTUAL CAPITAL INTO INTELLECTUAL PROPERTY

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Recruiting and training graduate students is becoming ever more challenging and costly. Maintaining a competitive edge is difficult in states like Kansas where monetary resources are in short supply. As a result, Kansas State University is continually searching for areas of competitive advantage—unique experiences and educational opportunities that might interest motivated students as much as extra cash. One such area that is being explored currently involves the commercialization of intellectual property (IP). The infrastructure for IP commercialization that has been developed offers an opportunity for recruiting and training future scientists with interests in entrepreneurship.

The Bayh-Dole Act

With the enactment of the Bayh-Dole Act in 1980, American universities have become increasingly involved in technology transfer—the protection and licensing of IP originating from the institutions' research endeavors. Prior to 1980, the federal government retained title to IP created on federally funded research projects, and the IP was lost to commercialization as a result. The Bayh-Dole Act changed that by allowing universities to retain title and requiring that commercialization efforts be explored. The federal government retains rights for use of the IP.

Most universities that have benefited financially from the Bayh-Dole Act have done so by patenting inventions emanating from the institution's sponsored research projects and licensing those inventions to major corporations. In optimal situations, the royalties and other revenues derived from those licenses exceed the expenses incurred in protecting and licensing the IP, but few such technology transfer operations are highly profitable.

K-State Technology Transfer

Kansas State University has been involved in technology transfer for many years, and the KSU Research Foundation [KSURF, an affiliated 501(c)(3) founded in 1942] facilitates these efforts. IP created at K-State that has the potential to be protected, licensed, and commercialized is assigned to KSURF. However, because there is no way to predict with certainty which technologies will be successful, a portfolio approach is used, i.e., technologies are screened for commercialization potential and the IP portfolio is “shopped” to potential licensees. Some technologies end up being licensed; some don’t.

Since 1995, KSURF has worked in collaboration with the Mid-America Commercialization Corporation [MACC], one of three innovation centers in the Kansas Technology Enterprise Corporation [KTEC] economic development network. The stakeholders that created MACC include KTEC, the City of Manhattan (with the Chamber of Commerce), and K-State. MACC’s mission is to promote technology-based economic development in Manhattan and the region, principally by facilitating technology transfer and the start-up of new, technology-based enterprises. To fulfill those tasks effectively, MACC must have access to K-State technologies with commercial potential, so teaming with KSURF was an obvious first step.

In the partnership that developed, MACC focuses on external activities by assisting KSURF in identifying potential licensees for K-State IP and negotiating the licensing terms on KSURF’s behalf. KSURF focuses on internal activities, primarily on identifying and protecting K-State IP and on managing the IP and license portfolios. In practice, though, the relationship between KSURF and MACC is transparent and seamless with staff from both entities working as a team across all interrelated activities.

During the early phases of the KSURF–MACC partnership, the traditional university approach to technology transfer was followed most often, whereby technologies are licensed to major corporations. There are problems with this approach, however, since most university research produces early-stage technologies that require significant investments in further development prior to successful commercialization. Many companies are reluctant to make these investments when they don’t have close working relationships with the inventors; K-State is at a disadvantage with so few major corporations nearby.

The TADAC Program

Fortune 500 companies commercialize only a small portion—perhaps 5%—of the IP that they have created, often investing considerable resources in research and development along the way. The reasons are many and varied for so little being commercialized, but the result is that the economic potential of the IP is lost or significantly reduced. Therefore, MACC launched the Technology Acquisition, Development, and Commercialization [TADAC] program in 1998 to acquire dormant or underutilized corporate technologies by way of tax-deductible donations. The intent is to foster the further development and commercialization of IP in the TADAC portfolio for local, regional, and national economic gain. In some cases this may be done via cooperative research with K-State. The rationale for a company to donate a technology is based on the potential tax advantage that can ensue.

Since the inception of TADAC, more than ten Fortune 500 companies have provided technologies to MACC, with the resulting portfolio having a valuation for tax purposes at the time of donation around $400 million. Comments from the IRS suggest that's about 40% of all patent donations nationally. The IP obtained to date falls generally in the categories of environmental quality, life sciences, information/communication, material science, manufacturing, and transportation. The technologies are available to scientists at K-State and other universities for research purposes, and they are available for licensing.

An example of a research opportunity emanating from the TADAC program involves an herbicide donation by *DuPont*. K-State agronomists have demonstrated extensive weed control for crabgrass and creeping bentgrass with the patented compounds. Corn and sunflowers are unaffected. The donated herbicide can be produced at low cost, and it can be applied at lower rates than many existing commercial products. As a result, the product offers significant commercial potential, and K-State research will be critical to realizing this potential. Accordingly, MACC is treating the technology in a manner similar to K-State technologies, with any royalty returns being shared with the researchers and their departments, as well as with KSURF.

Focusing on Start-up Companies

KSURF and MACC have focused more attention in recent years on licensing to local start-up companies as an alternate approach to licensing to major corporations. This method directly addresses MACC's local economic development/job creation mission, and in many cases it offers greater potential for significant financial returns on K-State IP. However, it does so at greater financial risk.

In this alternate model, KSURF or TADAC supply the technologies upon which the venture is based, and MACC provides business leadership for the start-up until the company matures sufficiently to employ its own management team. Most entrepreneurship models nationally are deficient in this aspect, and MACC's role in this regard is critical to the success of the venture. When K-State IP is involved, the creator of the IP usually has some role in technology development within the company. By launching a venture with K-State IP, KSURF and MACC secure equity positions in the company based on their contributions. If TADAC IP is involved, KSURF may or may not have a role and an equity position.

One difficulty with company start-ups is that KSURF and MACC must defer repayment of their expenses for many years—or permanently if the venture fails, as many start-ups do. The investments by KSURF and MACC often amount to tens of thousands of dollars, so there is considerable risk in pursuing this approach. Moreover, because of the magnitude of the investments and the associated risks, it is difficult to undertake a large number of start-up ventures simultaneously.

Launching Start-ups with SBIR Awards

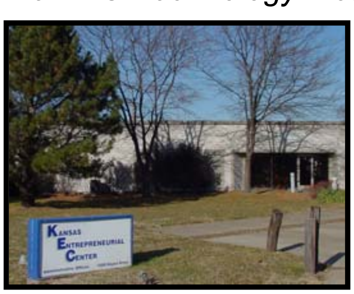
The federal Small Business Innovation Research [SBIR] program is a key component of the start-up company model that has developed, and without it, the commercialization of K-State IP locally would be nearly impossible. The intent of the SBIR program is to facilitate the development of early-stage technologies to allow their commercialization. As such, SBIR funds can serve some of the functions of very early stage seed capital but with the advantages of not diluting KSURF or MACC's equity positions or having to be repaid. SBIR Phase I awards provide up to $100,000 for six months of work to establish proof of concept. Depending on the federal agency, Phase II awards provide from $300,000 to $750,000 or more for two years of additional development work.

K-State, KSURF, and MACC have been exploiting the SBIR program to launch local start-up ventures since 1996, and the cumulative funding from this source exceeds $10 million. Initially, the start-ups may be "virtual" companies, having no dedicated facilities or company-paid employees. Procedures are in place to allow start-up company employees to conduct early portions of the work in K-State laboratories, with the costs for use of the facilities covered by the SBIR award. In the first ventures of this type, a new Kansas company was created for each different technology. However, because these efforts often fail at the proof of concept stage, a technology development company has now been created to facilitate these efforts—Kansas Advanced Technologies, LLC.

Role of the Technology Development Company

KANSAS ADVANCED TECHNOLOGIES [KATS], LLC. — *KATS* serves as a technology development enterprise focused on securing early stage funding, primarily SBIR awards, for KSURF and TADAC IP. As technologies mature with the infusions of SBIR funding and other resources, decisions are made as to the future potential for commercialization. In some instances, it may be appropriate to license the enhanced technology to a major corporation. In other cases, rolling the technology out into a separate start-up venture is the better choice. Either way, the value of the IP will have been enhanced.

The KEC Technology Incubator



The Kansas Entrepreneurial Center [KEC] serves as a business incubator, providing facilities and administrative support for technology-based start-up companies in Manhattan. The KEC is a controlled affiliate of MACC, with sponsorship by the City of Manhattan, the Manhattan Chamber of Commerce, Riley County, Pottawatomie County, K-State, and the KSU Foundation. The offices of KSURF and MACC are located within the KEC at 1500 Hayes Drive, Manhattan, KS 66502-5068. In optimal situations, start-up ventures will mature and “graduate” from the KEC into larger facilities locally, in some cases to facilities in the K-State Research Park.

Start-up Company Overview

Each start-up venture is unique. That said, in a “typical” scenario:

1. KSURF works with the K-State researcher(s) to patent a new invention;
2. KSURF, MACC, and the K-State inventor(s) determine whether a start-up venture is feasible and desirable;
3. MACC works with the K-State inventor(s) to develop one or more SBIR proposals;
4. A Phase I award is received by the company (normally KATS in the future);
5. The proof of concept work is carried out in the campus laboratories of the inventor(s) with facility use paid by the SBIR award;
6. A subsequent Phase II award is received by the company, and the project is moved from campus laboratories to the KEC; and
7. Venture capital and/or private investment money is obtained to move the development forward.

In most cases, recent K-State graduates are key staff on these start-up ventures.

The K-State Research Park

The K-State Research Park was developed in 2001 to promote cooperative relationships between K-State and private individuals, companies, and corporations. The primary activities conducted in the Research Park must be related to the teaching, research, service, and/or technology transfer activities at K-State. The KSU Foundation and K-State are developing the Research Park in a cooperative effort. The land on which the Research Park is located is owned by the Foundation and is contiguous with the K-State campus on Manhattan Avenue. This provides a potential site for companies to move from the KEC.

Start-up Venture Capital

MACC manages a seed capital investment fund, Manhattan Holdings, LLC, which can infuse early stage funding into new start-up ventures. This provides a source of funds for some costs not covered by SBIR awards. KTEC, the City of Manhattan, and the KSU Foundation are investors in this fund and, as a result, all share in returns on the investments. Monetary returns have already been realized on some early ventures.

Graduate Intern Program

A graduate internship program has been developed at K-State to provide students with practical experience in technology transfer. Sponsored by the Graduate School as part of the MBA Technology Entrepreneurship track, a limited number of MBA interns are currently taking part. They are participating in various aspects of the process at K-State (receipt of grants and contracts and disclosure of IP), KSURF (protecting and licensing IP), and MACC (IP assessment and facilitating local start-ups). The program is being expanded to include graduate students from various science and engineering disciplines, so the number of interns participating in the program should grow substantially over the next few years.

KSURF IP Start-up Ventures

NANOSCALE MATERIALS, INC. — *NanoScale* was the first start-up venture launched by KSURF and MACC, originally under the name of *Nantek*. Based on the work of University Distinguished Professor of Chemistry Ken Klabunde, *NanoScale* produces reactive nanoparticles with broad applications in environmental remediation and detoxification of hazardous chemical and biological agents. Started in 1995 as a virtual company, the first employee was hired in 1996 when an SBIR award was received. Since that time, *NanoScale* has received millions of dollars in SBIR awards and private venture funding; the company employs numerous K-State graduates. *NanoScale* moved into a newly constructed corporate headquarters and research facility in the K-State Research Park in 2002, becoming the anchor tenant there.

AGRENEW, INC. — *AgRenew* was organized in 1998 to develop and commercialize superior products and/or processes based on the use of agricultural waste products and byproducts. *AgRenew* presently has two primary commercialization targets. One is derived from the research of Dr. Susan Sun in the Department of Grain Science and Industry, and it involves composite products made from wheat straw and soy protein adhesives. The initial product is focused on edible, biodegradable containers for livestock feed supplements, and it is being developed in a strategic relationship with the industry leader in this field. The other target is derived from the research of Dr. Alex Mathews in the Department of Civil Engineering, and it involves the use of fermentation processes to produce environmentally benign, non-corrosive, biodegradable road deicers that can help protect the transportation infrastructure.

Nacelle Therapeutics, Inc. — *Nacelle* was incorporated in 2000 to develop and commercialize treatments for cystic fibrosis based on the research of Dr. John Tomich in the Department of Biochemistry and his collaborators at the University of Kansas Medical Center. Dr. Tomich's research team developed a novel family of transmembrane, ion channel forming peptides that show great promise for cystic fibrosis therapy. Current work at *Nacelle* is being undertaken with collaborators at the University of Alabama, Birmingham, who have developed specialized animal models to assess treatments for the disease.

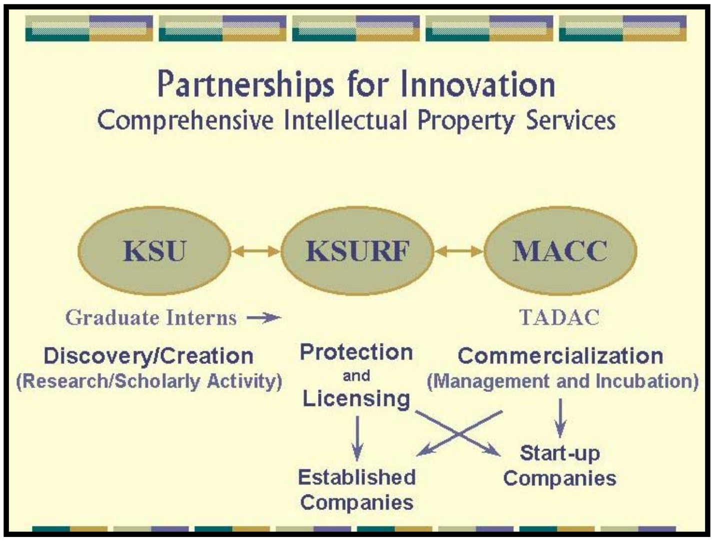
TADAC IP Start-up Ventures

NutriJoy, Inc. — Founded jointly by MACC and KSURF in 2000, *NutriJoy* was launched to commercialize a beverage technology from *Procter & Gamble*. The patented process allows milk protein and fruit juice to be mixed, yielding a shelf-stable product. One of the inventors, Dr. David Yang, was recruited from *P&G* to serve as the president of *NutriJoy*. *P&G* also included the rights to a proprietary calcium formulation that delivers a highly palatable calcium supplement that is more bio-available than any other form. It offers the only calcium nutritional supplement confirmed in clinical studies to increase bone mass in senior citizens. The first product taken to market by *NutriJoy* is *Cal-C*™, a calcium and vitamin C supplemented "smoothie" beverage available in four flavors. *Cal-C*™ has shown strong customer satisfaction in marketing efforts launched in Kansas and Arizona. *Cal-C*™ is also the subject of clinical research in K-State's Department of Human Nutrition to determine its effect on bone density in pre- and post-menopausal women.

Compact Engine Company, Inc. — The *Compact Engine Company* was created in 2002 to pursue the further development and commercialization of the compact compression ignition [CCI] engine. The patent rights to the CCI engine were acquired via a donation from *Caterpillar*, and the exclusive rights are licensed to the *Compact Engine Company* — a "virtual" company initially, with no dedicated funding or paid employees. The opposed-piston compression ignition engine provides improvements in emissions, power density, fuel efficiency, size, weight, and fuel tolerance. While the CCI engine could fit any market from chainsaws to automobiles, a more immediate customer need has been identified in unmanned aerial vehicles for the Department of Defense. As a result, initial efforts are being focused there.

Commercialization Overview

The overall process for commercializing IP is summarized in the following flowchart. The discovery/creation of IP occurs within K-State or via donation in the TADAC program. KSURF focuses on the protection and licensing of IP, while MACC concentrates on commercialization activities. The graduate interns can gain experience in all aspects.



Converting Intellectual Capital into IP

At K-State, one new approach for recruiting and training future scientists is to offer graduate students the opportunity to participate in the varied technology transfer activities that are ongoing. Aspiring scientists with entrepreneurial interests have the opportunity to experience the full range of IP services and commercialization practices—from academic theory to real world applications. Although it is still too early to assess the overall success of the graduate intern program, the results to date appear promising. Hopefully, some of the would-be entrepreneurs will utilize the intellectual capital they bring to K-State to create IP they can then commercialize. That would be a definitive measure of success.

CREATING WAVES OF CHANGE:

HOW IS THE BAYH-DOLE ACT SHAPING THE LANDSCAPE OF GRADUATE EDUCATION?

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The Bayh-Dole Act of 1980 legislated that universities could (and should) own and license intellectual property generated from federal research funds. Few will argue that this has not transformed university life. Licensing intellectual property can generate revenue. This newfound ability allows universities to play a bigger and more clear-cut role in the economic development of their regions. The success stories—such as Silicon Valley and the Route 128 corridor—have piqued the interest of the communities where universities reside. Local and regional partners now encourage their universities to focus energy and programs on creating economic wealth in the region.

These opportunities and expectations have generated a variety of changes within the academic community. As research administrators, we must ask ourselves: Is graduate education becoming a different entity altogether, or are we experiencing a short-term change? Have these new opportunities changed our values in fundamental ways? Do university policies reflect and support the changes we desire? This paper is an attempt to outline a number of questions worth considering as we near the 25-year anniversary of the Bayh-Dole Act.

Academic-driven Economic Development: Have We Oversold the Story?

Obviously, university research has the potential to play a critical role in the economy, and in fact does. But, two questions concern me. First, has the focus placed on research growth and research expenditures overshadowed the central role of discovery, creation, innovation and scholarship in the academy? Second, if state legislators tie support for state universities to "economic outcomes," what happens to the sustainability of graduate education if we don't deliver in clearly measurable ways?

There is no question that universities are telling their stories about economic development to anyone and everyone who will listen. One rarely sees research being justified in the context of scholarship—what was once considered the central role of a university in the education of its students. The story almost always tries to put research into economic terms. All academic chief research officers are now skilled in pointing out: the "economic multiplier" of their research operation; the number of jobs that each new dollar of research creates; and the potential for research to spawn new high-tech companies that will transform their region. The new focus on the economic benefit of research has permeated almost every aspect of research on a campus. For example, even ecologists are now trying to justify their research in terms of the economic services that ecosystems provide.

Yet, there are really only a few true success stories. In Silicon Valley, the universities were drivers of major economic change. The economic multipliers are real, but now Governors (in some states) are asking universities to identify the “jobs,” “companies,” and economic outputs that were truly generated by research. At some point, if more “success stories” do not arise (and most universities do not have the potential of the Silicon Valley, Research Triangle, or Boston), will our legislative branches and our communities consider our “economic analyses” academic hyperbole? If they do, where will we be?

Has a New Focus on Owning Intellectual Property Changed Graduate Education?

The Bayh-Dole Act has brought about a fundamental shift in philosophy regarding the dissemination of research results. Prior to 1980, almost every faculty member and administrator prided themselves on the role of academe in the free-flow of information. At the institutions where I went to school, I never heard a discussion about restricting publications in order to protect intellectual property rights, let alone the idea of keeping doctoral theses confidential so as not to disclose intellectual property. Chief research officers are now having these discussions on a daily basis.

This has led to other issues. When I left graduate school, the university was not concerned if I could take with me or continue to access freely the data I generated as a graduate student. In other fields of research this was often a concern of major advisors, but generally not of university lawyers. Now, we are all trying to develop data policies that make it clear where ownership of data resides, including graduate-student data—and these policies need to hold up to legal scrutiny. How does this change affect graduate education? Are we adequately addressing expectations about access to data once a student leaves, so problems don’t arise later?

Not all aspects of academe have caught up with the changes caused by the Bayh-Dole Act. One example is the promotion and tenure process. From my experience, most promotion and tenure (P&T) committees still look at accomplishments in traditional ways. They look at publications, particularly single-authored publications: How many are there and what journals are they published in? They look at competitive grant funds. From my limited experience, few P&T committees have adapted to handle the new focus on protecting intellectual property. The patent process is extremely rigorous, but I have found that patents are rarely valued to the same degree as peer-reviewed publications. Licensing income is not viewed on a par with competitive grant funding. Yet, researchers understand the high value placed on making one’s research available for driving economic growth—this is a primary goal at the university-level. Although I know that some institutions have managed to develop policies and procedures to address this change, I would argue that few have truly changed the promotion and tenure culture in a systematic way. Do we need to?

Chief research officers expound the value of interdisciplinary research and collaborations. Yet, interested graduate students must navigate a minefield of technical issues in intellectual property ownership before they can begin such collaborations. Are we sending mixed messages? If we are, how can we help the next generation get through the conflicting aims we all have?

The “Porsche in the parking lot” story is not uncommon. Once someone on campus gets a big intellectual property deal, he buys a Porsche with the income, parks it in the parking lot for all to see, and the other faculty jump on the band wagon to try and license every idea they have ever had. Those of us who are trying to develop more active technology transfer operations want to promote this sort of drive in our faculty. But, the widely known financial success of some university inventors has led to inflated expectations among new graduate students. Some students now want to become university researchers so they can “get rich” with the intellectual property they will generate. These are fundamental changes in attitudes for our traditional programs. How well have we become acclimated to this change, or should we?

How has the Institutional Emphasis on Economic Development and Private Sector Partnerships Affected Academe?

At my institution economic development is being clearly articulated as a 4th mission—joining education, research and service as the defining goals. Does this create confusion about our core mission? For example, is a business incubator a higher priority than a performing arts center, investment in research collections, or a new humanities building? Priorities have not yet been thoroughly sorted out by most academic communities.

Partnering with the private sector means on-time, within budget, deliverables that we have not traditionally known in academe. Hiring research faculty, technical staff and postdoctoral fellows is often more attractive than training graduate students when the ability to “deliver” is emphasized. Furthermore, it puts more pressure on directing, or even micro-managing the research projects of graduate students. Does this change the nature of graduate education in the research university?

Strategic planning to identify key areas of research investment is a process each university has underway. I have noticed the tendency to focus on research strengths with ties to economic development. At the University of Missouri-Columbia, our focus is the life sciences. This has the potential to alienate some areas of academic excellence; my institution has several world-class humanities research programs. Are we in danger of reshaping and refocusing inalterably? Will this change diminish the full range of graduate programs in lieu of strengthening the ones driven by technology?

Now that we have identified a clear role for universities in driving the economy and developing partnerships with the private sector, we must recognize that the private sector can more easily influence the university. Influential members of a community can use their access to legislators and institutional leaders to steer the focus of a university toward meeting their desired economic goal. State-supported universities welcome the support of business leaders. They are valuable allies. But, are we prepared for the potential costs?

Summary

This short muse is my attempt to point out some fundamental ways that the Bayh-Dole Act has changed the nature of universities, and hence some aspects of graduate education. The intellectual property housed in universities is perhaps the most valuable asset a university has. In state-supported institutions, it may be the most valuable asset owned by the state. Bayh-Dole's directive to universities to own and financially benefit from intellectual property has been a boon. Some universities have prospered from the new source of revenue. Others have not seen the financial gains, but now have supporters in the business community with a vision for the university's role in economic development. These are positive changes. Yet, some of the changes conflict with the traditional core values of academe, and many sectors of the academy are still adjusting.

For every question I have raised in this paper, I have the same answer—"I don't know." At this point, I am unable to do more than ask questions and point out dilemmas. The rate of change is fast, and the effects of owning intellectual property are far reaching. I can only hope that by reflecting on the vast repercussions to the whole fabric of academe in this instance, we are better prepared to avert the consequences of another legislative act that may be right around the corner.

DIFFUSING GRADUATE REFORM INITIATIVES IN THE SCIENCES:

HOW MIGHT "INSTITUTIONALIZATION" REALLY WORK?

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University of Nebraska - Lincoln

Calls for innovation and reform in graduate education are now ubiquitous. Many federal agencies and foundations fund national efforts to initiate graduate reform movements, and these programs have no doubt benefited faculty and students who have been directly involved. But most of these programs carry an expectation that universities will attempt to diffuse or "institutionalize" the funded interventions beyond the original participants. As a result, administrators face a practical question: What conditions make it more likely that an isolated innovation or reform will be diffused? This paper will address several strategies that may facilitate institutionalization of higher education reforms.

An Example: The Carnegie Initiative on the Doctorate and the University of Nebraska-Lincoln Department of Mathematics

The Carnegie Initiative on the Doctorate (CID) is a multi-year research and action project designed to support efforts to more purposefully structure doctoral education in six core disciplines. The Carnegie Foundation believes that it is time to return to first principles, and so the project centers on the essential question, "What is the purpose of doctoral education?" The initiative has three interacting elements: a conceptual analysis of doctoral education, design experiments in departments, and research and dissemination about the process used by departments to reform doctoral education. Faculty and departmental leadership in the disciplines is a crucial focus of the initiative. Chris Golde, senior scientist for the CID, states that the project sought departments that are committed to being "stewards" of the discipline. Specifically, they selected departments that have a keen sense of the heart and essence of the field, but also have a critical eye toward the future—and those departments willing to take risks to advance doctoral education in the discipline.

The University of Nebraska-Lincoln's (UNL's) Department of Mathematics was selected as one of eight Math departments nationwide to participate in the CID. The questions that UNL's Math department will address in their CID project include:

- Is a curriculum emphasizing broad knowledge of mainstream mathematics still appropriate?

- What revisions of our curriculum and degree requirements are necessary in order to accommodate interdisciplinary research?
- How do we best prepare Ph.D. students for the jobs they will actually obtain?
- How can we increase recruitment and retention of underrepresented minorities?

The UNL administration was pleased to have the Mathematics department included in the CID, and it was obvious that the questions they were posing for themselves were valuable. But it was equally obvious that other departments on campus were ready to undergo a similar reform process, and could benefit from the kind of activities that Mathematics would experience during the CID. The task faced by the Office of Graduate Studies then, was to develop a plan for diffusing the process and outcomes of the CID project to other departments on campus. As a starting point for this plan, two recent studies of higher education reform were reviewed.

Models of Change in Higher Education

Two recent empirical studies have investigated the conditions under which innovation and reform are best diffused in higher education. Eckel, Green and Hill (2001) surveyed 26 diverse institutions that sought to institutionalize reform initiatives. They studied factors that facilitated both the depth and pervasiveness of resulting change. Quehl, Bergquist and Subbiondo (1999) surveyed 49 universities to understand the diffusion of innovation in the pursuit of improved academic quality. Results from these two studies suggest a series of specific recommendations concerning the conditions that may facilitate reform, and the actions that administrators can take to maximize the effects of these conditions. The following discussion uses UNL's attempt to diffuse the CID reform process as a context for illustrating these recommendations.

Conditions that Facilitate Reform I

Look for propitious external environments and internal conditions.

A "propitious" external environment certainly exists. There is considerable agreement about the need for change in graduate education, especially in the sciences. Examinations as narrow as the 1995 COSEPUP report on reshaping graduate education in engineering and the sciences, and as broad as the 2001 Pew report on doctoral education suggest that a new approach is needed. This approach should emphasize adaptability and versatility as well as technical proficiency. Furthermore, professional organizations and funding agencies now ubiquitously call for the diffusion and institutionalization of these reform initiatives.

At UNL, equally propitious internal conditions also exist. In 2000, faculty leaders developed a strategic plan for the future of graduate education and research on our campus. This plan states that "Graduate programs are preparing future professionals in the professorate, in professional practice, in public policy roles and in private research and industry. We need institutionalized programs that will prepare students' career paths in the wide range of positions taken by our graduates" (Future Nebraska Task Force, 2000, p. 39).

Clearly the internal and external environments on most university campuses provide sufficient support and motivation for graduate reform initiatives.

Conditions that Facilitate Reform II

Think locally, but look globally when conceptualizing.

The reform literature suggests that nearly every effective local innovation has a national model as a guide, and these models are most acceptable when they come from a credible source. Given this, the CID project provides an ideal model to use as the basis for local diffusion efforts. The Carnegie Foundation has significant status and credibility among faculty across all disciplines. Modeling a local UNL initiative after the Carnegie project would likely create interest in the local initiative.

Given this, UNL will create the "Nebraska Initiative on the Doctorate (NID)," closely modeled after the CID. UNL will commit funding to provide many of the same resources and incentives that Carnegie provides to CID participants, including:

- Structural framework: the milestones for progress and timelines;
- Materials and tools: commissioned essays, materials that help faculty document and reflect on student and faculty experiences in the doctoral program;
- Site visits: a consulting team that serves as a sounding board and provides assistance;
- Moral support: assistance of many kinds at key points in the project.

The UNL Mathematics department will serve as a communications conduit to the CID and will partner with other UNL departments to share CID materials and resources. The ultimate goal is to literally diffuse the CID model to additional UNL departments by combining UNL funding and shared materials from Carnegie.

Conditions that Facilitate Reform III

First think small and simply, then more expansively.

The next logical administrative question is: Which departments ought to be included in the local reform initiative? While it may seem wise to have ambitious goals for institutionalizing a reform project, the literature suggests that a more controlled phase-in is more likely to succeed. The CID is a multi-year project, and so it might be logical to phase in a small number of UNL departments during each year of the Math department's involvement in CID. Perhaps UNL could accommodate two new departments per year in the NID, so that administrative and fiscal resources are likely to be sufficient to ensure the success of the project.

The two research studies cited above suggest that selecting the departments to include in a reform initiative should be done thoughtfully. The innovation must be on the right topic at the right time in the department's development. Department leaders must be able to frame a positive change agenda and honor unique norms of governance in the department when designing the specific reform processes to be employed. Finally, most successful initiatives require that the department faculty feel some sense of urgency for reform and be ready to follow self-imposed deadlines to move the project forward.

Conditions that Facilitate Reform IV

It takes sufficient money, time and institutional commitment.

Both studies demonstrate that it is a mistake to begin an innovation without a commitment to ongoing funding and support. The institution must view such commitments as investments designed to support important forms of academic change. Institutional commitments can take many forms, but should include public commitment from university, college and department administrators. Empirical results suggest that release time for faculty and staff is highly correlated with success of reform initiatives.

Conditions that Facilitate Reform V

Leaders with attitudes and strategies that facilitate change are needed.

Reforms are most successful when leaders help people develop new ways of thinking, intentionally create time and space to examine the status quo, and design opportunities for engagement with outsiders and new ideas. Both studies cited above report that leaders of successful reforms paid attention to the change process and adjusted their actions as needed, and understood that process issues are often a source of contention (e.g., who is consulted, how decisions are made). Finally, effective leaders of reform projects were willing to balance speed, deliberation and persistence as they moved through the change process.

Summary

Graduate deans and other campus administrators face the practical task of diffusing isolated reform initiatives. While most funding agencies expect reforms to be institutionalized, few systematic efforts to diffuse reforms actually occur. The purpose of this paper was to describe straightforward and concrete issues for administrators to consider when attempting to diffuse reforms. The results of two empirical studies suggest that administrators should: create environments that urge change; base local reforms on the diffusion of credible national innovations; start small and then expand by selecting departments that are ready for change; begin an innovation only if on-going support exists; and provide leadership that facilitates change.

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PROJECTS, PROCESS AND PIPELINES:
CHALLENGES TO ENHANCING THE SCIENTIFIC LABOR FORCE

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What I really want to talk about today is *change.* We often use the word *institutionalization* to "name" what we consider lasting changes. Ellen Weissinger addressed this question in another context today. What I want to talk about is a broader question. To expand and enhance the scientific work force, I agree with Robert Barnhill that we must promote diversity in higher education. This is fundamentally about social change. In my remarks, I will draw on nearly 25 years of experience observing and developing initiatives designed to foster inclusivity in higher education.

When we talk about policy, it is important to distinguish between programmatic or outcomes-oriented policies and policies that define core processes. In the field of law, there is a distinction between the substantive and the procedural. I want to use this same distinction to talk about policy today. Further, I want to make the claim that policies based in substance are seldom proactive. They are almost always developed and written in response to a problem that has been defined by either a wide group of policy makers and constituents, or by a narrow but powerful and influential group of opinion leaders. Because enactment of policy usually depends on a coalition of interest groups, it is often written at a very general level. Although all parties agree upon the general problem, they may very well disagree about the nature of the problem. Furthermore, implementation of policy is often less public than its enactment; it rests in the hands of administrators and bureaucrats whose typical response is to develop and initiate a series of programs and projects.

The approach of going from policy to program rarely "sticks." When initial funding sources dry up, the programs devised in response to specific policies atrophy or disappear entirely. The question of course is why. The typical response I hear is that it takes a visible, committed leader. While I agree that leadership is extremely important, like funding, leaders also "go away." So what does undermine our capacity to create lasting change? Where are the gaps between the time we first identify the problem, formulate the policy, and implement the programs? I want to make the case (and it really isn't particularly novel) that the primary omission is our lack of attention to core processes.

I think we all can agree that U.S. higher education is characterized by a rather startling lack of diversity, a lack that becomes more pronounced at each succeeding educational level and is particularly striking at a time when demographic changes are literally transforming the face of America. Certainly, in 1954, the U.S. Supreme Court took the first step in dismantling the *il*legal, overtly discriminatory bases of educational segregation. The 1954 decision has now been followed by almost 50 years of federal, state, and institutional policies and programs designed to foster inclusion. I won't go through the list—you know them well. Nevertheless, despite some truly remarkable and important successes, most of us would have to concede that the problem of access and diversity has proven rather intractable.

Along the way, our understanding has changed. We have moved beyond seeing educational inequality as overt acts of discrimination and now see that inequality is a by-product of institutional structures. Likewise, we have also grown beyond seeing affirmative action as a remedy for past injustice to a view that diversity is a positive educational goal (as in the recent Michigan Supreme Court case). When we don't agree on the fundamental nature of the problem and the goal, this creates additional problems in trying to devise appropriate institutional responses.

Let me give a specific example. As most of you know, in addition to intellectual merit, the National Science Foundation now includes a "broader impact" criterion as part of the graduate predoctoral fellowship awards process. Included under broader impacts are such factors as contributions to diversity and social benefit. In large part, this change was designed to get around legal challenges to earlier targeted fellowship programs for racially and ethnically under-represented groups. The number of applications from members of these groups did go up during the 2002-2003 cycle, but the total applicants—and more importantly, the number of awardees—remains low. Similarly, programs such as the Ronald E. McNair Postbaccalaureate program and GradPortal have increased the pool of applicants from under-represented groups seeking admission to U.S. graduate schools—these programs have great promise. Somehow, though, the number of graduate students and Ph.D. faculty from minority groups remains disappointingly low.

An examination of how the NSF fellowship panels are briefed and make decisions may help to illuminate where the **process** breaks down. NSF fellowship panels are given little clear- cut advice on how they should evaluate the various aspects of the broader impacts criterion. Furthermore, they are given little guidance on just how much weight should be given to this component in the overall evaluation of candidates. Although NSF clearly states the importance of diversity and the broader impacts criterion to the agency and its mission, panel leaders and individual panelists are simply instructed to follow their own personal ideas on the appropriate weight to give. Because it is relatively undefined and under-discussed, the broader impacts criterion, in practice, becomes a secondary selection factor, used only after the traditional intellectual merit criteria are fully and equally satisfied.

In point of fact, I believe this same process occurs time after time on my own campus. Despite an incredibly rich array of diversity programs and a rather generous institutional investment in graduate fellowships and assistantships for students from racially and ethnically under-represented groups, the progress we are making over the last several years is incremental at best. Why? Because graduate admissions committees often treat diversity in much the same way as NSF fellowship panels do; it is a secondary consideration after standardized test scores and other academic credentials are taken into account. This leads me to believe that the admissions process must be changed so that diversity (along with traditional academic indicators) is one of the core admission criteria. The rationale for including diversity in this way has now been firmly established by the empirical work of Pat Gurin and her associates; they have demonstrated that educational benefits accrue from diverse learning environments. A logical extrapolation of this finding is that a diverse student body is a necessary precondition to a quality education.

What holds at the institutional level should also hold at the level of departments and programs. Interestingly, when I have discussed this issue with the directors of our 90+ graduate programs, I found remarkably wide agreement, across the full range of disciplines; they agreed that diversity should be included as one of the 3-5 core indicators we use institution-wide to evaluate program quality and make related resource decisions. Although we still have some work to do in making this kind of assessment plan a reality, I believe we are within a year or two of doing so. Once we embed diversity in core admissions and resource allocation decision-making processes, I believe we will close the gap between policies and programs. At that point, we will have a real chance of institutionalizing access and diversity as core principles at the University of Missouri.

Now to the question of recruiting and training future scientists. At its heart, I think the fundamental problem is the declining percentage of domestic students in science, technology, engineering and mathematics (STEM) graduate programs, especially at the doctoral level. We fear that if we do not find a way to expand their numbers, the U.S. will lose its competitive edge in an increasingly global and knowledge-based economy.

It would be an interesting experiment to deconstruct, as Debra Stewart did earlier, all of the various stakeholders on this issue, but I want to focus on what faculty (and Vice Provosts for Research) often appear to have in mind. Most worry, I think, about an impending shortage of Ph.D. students capable of independent scientific research. A subtext is a worry that there will not be enough students to fill the labs that support scientific research *as it is currently practiced*. Although there are an increasing number of reasons to believe that science in future generations will not be practiced as it is now, our dialogue about recruiting and retaining a scientific labor force is still largely driven by the needs and structure of existing doctoral programs.

There is a countervailing force, however, that conceptualizes the "problem" of a shrinking scientific labor force differently. This perspective comes from the Sloan Foundation, industry, and other non-academic constituents. They believe that science in the future will require more master's and MBA-prepared scientists, and not necessarily more Ph.D.s. To this end, they are developing funding policies that nurture a different type of educational program. In fact, these policies (and programs) ultimately may change NSF-funding policies to include opportunities for more master's-level students.

If this alternative conceptualization of the "recruiting and retaining scientists problem" gained momentum and produced more programs on our campuses, what would be required to institutionalize these programs? My best guess is that some basic process questions would need to be resolved. Certainly, one critical issue would be the development of mechanisms that would govern/facilitate the movement of students between the two emerging tracks in STEM graduate education—the basic science/doctoral track and the more applied/professional master's track.

Another key element to enhancing the recruitment and retention of the scientific labor force resides in the shifting balance of international and domestic students. Driven by policy changes that lie outside the scientific domain, the [pre]dominant role of international students in graduate education in the STEM fields is under increasing scrutiny. This, in turn, has increased concern about the large segments of U.S. society that are uninterested in and/or under-prepared for advanced scientific education. Of course, any thoughtful exploration of this question, in the end, will lead us back to questions about diversity. The diversity question, in turn, leads us back to an assessment of the programs designed to increase access—GearUp, Talent Search, and Science and Math Upward Bound, for example. Ultimately, we face the conclusion that developing programs in the absence of sustained attention to core processes and systems simply has not, and perhaps cannot, produce sustainable change.

To know what works, we should know more about:

- how people learn science and math;
- what piques their interest as children;
- cultural or economic barriers at key transition points in the science pipeline;
- how graduate students and post-docs are recruited, prepared, and placed;
- which funding mechanisms support young researchers; and
- how scientists move between industry and the academy.

One change is clear; we must do away with the old hierarchies that give greater value to scientists than to science educators. To come full circle, we will need to develop a system of scientific education capable of creating a scientifically and mathematically literate citizenry. These well-informed citizens can then "weigh in" with policymakers on issues of importance to us all.

THE IMPACT OF POLICY ON INTERDISCIPLINARY GRADUATE EDUCATION AT IOWA STATE UNIVERSITY

John E. Mayfield
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Iowa State, like most other universities, is administratively structured with departments reporting to academic colleges. Faculty appointments are in departments. Graduate programs that grant advanced degrees are called graduate majors. Most graduate majors draw their faculty from a single department; but, at Iowa State, twenty-two programs draw faculty from multiple departments. These are designated "interdepartmental majors." Six interdepartmental majors report to an academic college, one to a department, and fifteen to the Graduate College.

In the fall of 2002, 782 graduate students were enrolled in these 22 programs (436 in the fifteen programs reporting to the Graduate College). This was 20% of all degree seeking graduate students. Growth in interdepartmental graduate programs has averaged 9% per year over the past 6 years. Over this period, four new programs were added and a fifth is expected this fall. Such growth is likely to continue in the foreseeable future. Most of the programs (sixteen) and most of the growth is in the sciences or engineering.

Earlier, Jan Buss told you about one of our oldest programs, Molecular, Cellular, and Developmental Biology (MCDB). I would now like to introduce one of our newest, **Bioinformatics and Computational Biology** (BCB). The program officially began in the spring of 1999 and now has 48 students enrolled (mostly at the Ph.D. level).

The program time line is instructive:

Fall 1997: Faculty in Mathematics and Biology realized they had common interests and held a faculty seminar on "Bioinformatics" (about 20 faculty attended).

Spring 1998: Creation of the Iowa Computational Biology Laboratory—essentially a web site where faculty shared their interests.

Fall 1998: Formal proposal developed for a graduate major and the approval process initiated. The Graduate College provided active assistance by shepherding the proposal through the approval process.

Fall 1998: Preparation of an NSF IGERT proposal.

Spring 1999: Creation of a budget line for three proposed new programs in the computational sciences, one of these was BCB.

Summer 1999: Approval of the new major by the state Board of Regents.

Summer 1999: NSF IGERT training grant awarded.

Fall 1999: Students were allowed to transfer to the new major and new students recruited.

Fall 2000: First recruiting class of 11 new students (25 students total, including transfers).

Spring 2002: USDA MGET training grant awarded.

Spring 2003: Sixty-seven faculty and forty-eight students representing twelve departments and three academic colleges.

The program and its students are now firmly engrained into the research and graduate training fabric of the life sciences and provide an important bridge between the life sciences and the computational sciences and engineering.

By most measures, interdepartmental graduate education at Iowa State is a success story. Janice Buss talked about why faculty are willing to spend time and effort to make these programs succeed. The short answer is that the programs are able to recruit better graduate students. I wish now to turn to how university policies affect interdepartmental programs.

I pose two questions:

- What policies are responsible for the success we have had?
- What new policies would make the interdepartmental program environment even better?

Existing key policies:

1. (Absence of a policy) graduate majors need not be associated with a single department.
2. The curriculum requirements of every graduate major are established and maintained by a defined group of qualified faculty. These faculty need not have their appointments in a single department or academic college.
3. When the faculty constituting a graduate major hold appointments in different colleges, the Graduate College usually serves as the administrative home for the major.
4. Students in interdepartmental majors have a “home department” (normally the department of their major professor) for non-academic purposes.

5. Academic appointments, and tenure and promotion decisions are made in departments and academic colleges, not in interdepartmental programs and not in the Graduate College.
6. Academic programs are distinct from research centers and institutes.
7. The Graduate College has a significant (though inadequate) budget to support the programs it administers.

Issues that need to be addressed by new policies:
1. Interdepartmental programs need access to financing budgeted at the university level.
2. Interdepartmental programs need to have influence on faculty hiring.
3. Faculty activities (teaching, service, administration) in interdepartmental programs need to be recognized and valued by their department and college.

What might the needed policies be?

Budget

If current trends continue, within the next ten years, there will be thirty or more interdepartmental graduate programs at Iowa State enrolling more than one-third of all graduate students. The budgeting process must begin to recognize this important aspect of the educational enterprise.

A very simple way to address the problem would be for the University to establish an annually incremented fund that would allow interdepartmental graduate programs (or groups of programs) to compete for long-term (budgeted) funding. $50,000 per year in operating expenses (less that .01% of the budget) for three years would have a huge impact. Matching with academic colleges would make colleges more aware of the importance of these programs to the success of their faculty and departments.

Another idea would be head-count budgeting. It is estimated that effective programs cost about $800 per student per year excluding the cost of faculty and graduate stipends. Institution of such a policy, if not tied to individual programs, would provide a growing budget as more and more programs attracted more and more students.

Influence on Faculty Hiring

This past year, the Provost put out a call for new faculty hires that could be justified in three ways:

1. departmental need
2. continuation of previously funded academic initiatives
3. interdepartmental program need

The addition of the last justification was unprecedented at Iowa State, and resulted in at least four requests made jointly by departments and interdepartmental programs to fill critical staffing needs. Three of eight approved positions involved an interdisciplinary graduate program. If this rationale were to become standard operating procedure for new hires, then this simple policy change would have a major positive impact on the quality of education delivered by interdepartmental graduate programs.

Recognition by Departments and Colleges

Interdisciplinary (interdepartmental) education and research must become a fundamental aspect of the university, college and departmental thinking. Appropriate wording changes to mission statements would be simple, but it is not so simple to make mission statement wording translate into effective action. **A strong effort needs to be made by the President and Provost to establish a culture of interdisciplinarity**. In concert with this, a series of detailed policy changes at the College and department levels would need to be made that recognize contributions made by faculty to interdisciplinary activities. The Graduate College must continue to raise this issue and to provide leadership when appropriate.

Conclusion

A major change that is occurring in graduate education today is the increasing role of interdisciplinary programs. These programs provide flexibility that is difficult to achieve within the traditional departmental structure, and they often appeal to the best students. Universities that are not able to adjust to and effectively support interdisciplinary programs will suffer, and Universities that are able to create environments in which they thrive will benefit. Graduate schools must provide the leadership needed to change campus cultures that determine the success or failure of such programs. Policy details and budgets both play critical but different roles in the success or failure of interdisciplinary graduate programs.

KEYNOTE ADDRESS – Day 2

GOOD NEWS, BAD NEWS:

GRADUATE STUDIES AND RESEARCH IN THE CANADIAN CONTEXT

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Dean of Graduate and Postdoctoral Studies, McGill University

This paper focuses on several of the essential elements in the link between graduate/postdoctoral studies and research. It includes questions and issues related to the funding of research and of graduate students, the retention and graduation rates of graduate students, innovations in graduate programs, the need for professional skill training and education on the responsible conduct of research, the place of postdoctoral fellows in our university, and the importance of the full spectrum of science and humanities research and scholarship.

Increased Federal Support for Graduate Studies and Research

There has been considerable good news for research and graduate studies in Canada over the last five years. Most importantly, they figure very squarely in the national agenda. For the last six years the government invested substantial sums of money in higher education and research. The Canada Foundation for Innovation was created to provide competitive funding for the re-equipping of university research facilities. The Canada Research Chairs, a program designed to provide salary enhancements that would bring outstanding researchers into our universities, was the next federal initiative. The allocation of these Chairs is based on the relative size of the operating research grants in each university.

In light of these innovative investments, at the 2001 annual conference of the Canadian Association for Graduate Studies, we explained to the representatives of the governments of Canada and Quebec the essential nature of graduate education in the scientific, social and cultural development of our nation. At this time the Quebec and Canadian government officials were confronted with what is now referred to as the “Godmother’s Promise,” that is, an offer that the governments could not refuse. I promised on behalf of the Canadian Deans of Graduate Studies that our universities would produce well run, cutting edge graduate programs, highly skilled personnel, and timely and high graduation rates in return for increased funding for graduate students. However, in that year’s budget graduate students were left out of the federal funding initiatives, taking a back seat to increased spending on national security.

Last year, the Canadian federal government announced a strategy for innovation aimed at moving Canada from 15th to 5th in the world in research and development. This strategy emphasized the importance of highly qualified personnel in research and development—in other words, people with graduate degrees. The retirement bulge in Canadian universities has meant that large numbers of people with doctoral degrees will be needed in our universities. Half of these positions will be in the humanities and social sciences. The prediction is that, overall, 80,000 more people with graduate degrees will be needed in Canada by the year 2011. This is approximately twice as many as our universities would normally graduate in that time period. In line with these predictions, the 2003 federal budget announced the creation of the latest of their educational investments: the Canada Graduate Scholarships. These scholarships provide $35,000 per year to doctoral students for three years and $17,500 to master's research students for one year. In addition, the Quebec government provided full tax exemption on all merit based graduate scholarships, including money paid to graduate students from research grants.

So what could possibly be the bad news?

Having received the good funding news, Canadian Deans of Graduate Studies are now asking themselves if the scholarships are too big and their duration too short. At $35,000 doctoral funding is now equal in size to the national research councils' postdoctoral fellowships. This has made many postdocs uncomfortable and put pressure on professors to increase postdoctoral funding from their own research grants. Furthermore, is it realistic to think that most doctoral students will complete their degrees in three years? It would have made better sense if the government had consulted more broadly on their plans for these scholarships.

More Bad News: Times to Degree and Graduation Rates

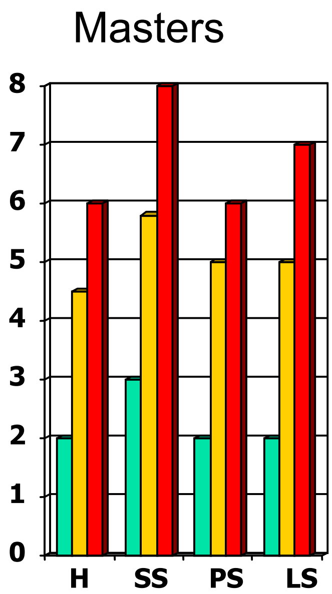
In response to the need for more graduates, a number of Canadian universities became aware that there are real limits on the space they have for increased admissions of graduate students. Consequently, attention has been given to two other alternatives for graduating larger numbers of graduate students: higher graduation rates and faster times to completion. Faced with this realization and remembering the bold offer to the government, the top research intensive universities in Canada, somewhat belatedly, decided to investigate what the actual times to degree and graduation rates of their graduate students really were.

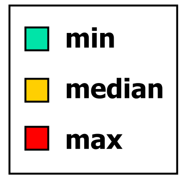
The 1992 cross-university cohort study of all doctoral and research master's students was not simple to design. Ten universities had to agree on definitions and how to count their students. This, alone, took two years. The study investigated three factors associated with retention: graduation rates, time to completion, and time to withdrawal or leaving. In short, the findings of the study were not good news (Berkowitz, 2003).

Graduation Rates. As the following graphs reveal the percent of students graduated varies from one university's low of 46% of their humanities master's students to a high of 91% of the master's students in another university's life science programs. The minimum master's level graduation rates across the disciplines varied widely. At the doctoral level the university with the lowest graduation rate was one that only graduated 34% of its doctoral students in humanities after 10 years. Overall, the graduation rates in the humanities were the lowest. The social sciences had higher rates and the physical sciences were even more successful with the median university graduating 70% of its students. The life sciences graduated the most students. The minimum graduation rates, particularly in the humanities and social sciences, were alarmingly low, especially considering the national need to graduate highly qualified personnel in all disciplines.

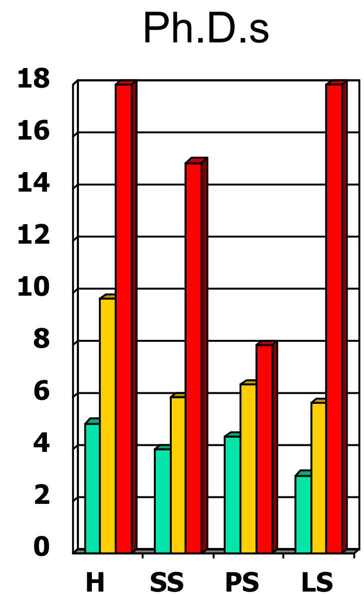
Times to Completion. The times to completion were not good news either. Measured in semesters (NB: a number of Canadian universities only register their graduate students two semesters in the year), at both the master's and doctoral level, median times to completion were higher in the humanities and social sciences than in physical and life sciences. In a humoristic comparison with the 8 deans of graduate studies who sit on the Executive Committee of the Canadian Association of Graduate Studies, I noted that across the disciplines our times to completion were lower than the 1992 cohort. Are deans outliers or have things gotten worse? Data from the Council of Graduate Schools confirm that times to completion in the United States have become longer over the last decade.

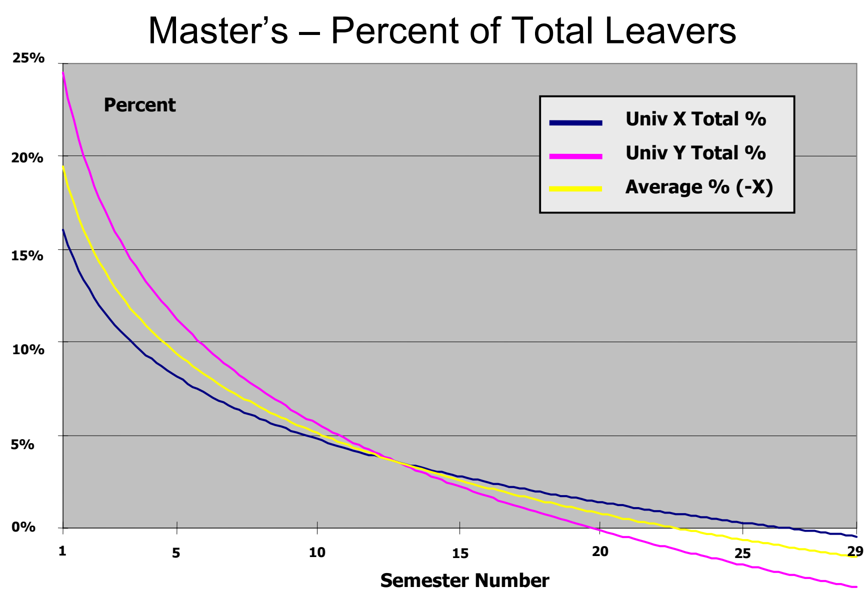
Times to Withdrawal. Finally, the time it took students to leave their university, either from free or forced choice, were investigated. The shocking thing about these results is that the times it took for students to leave a university were nearly the same as the times to completion. At some universities students were leaving after 8 semesters at the master's level and after 18 semesters at the doctoral level. Previous work by Nerad and Miller (1996) has indicated that there are two patterns of leavers. Some decide for good reasons to leave earlier than late leavers who appear to run out of steam or money after as many as 8 or more years of studying. Note the two graphs with smoothed curves depicting one university with more early leavers and another with more late leavers. The personal and institutional expense of graduate students leaving without a degree after more than 8 years of study is truly an educational tragedy.

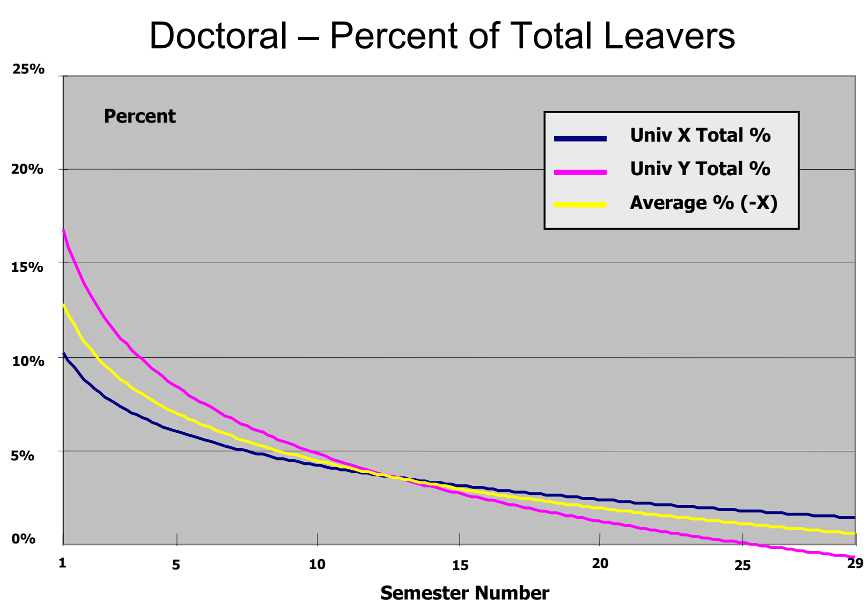




- **SS**=Social Science
- **PS**=Physical Science & Engineering
- **LS**=Life Science
- **H**=Humanities







Factors Affecting Retention

A number of recent studies have pointed to important factors that affect doctoral attrition (Golde, 200; Lovitts, 2001). Among these factors are graduate student funding, program design, academic participation, quality admissions and advising and progress tracking. The identification of these factors is helpful but many questions remain about what universities can actually do to improve retention rates.

There are questions about funding mechanisms, such as, what forms, rates and duration of funding will have the most impact on graduate retention. There are also questions about what form of program design will have the most positive impact on learning as well as on retention. We are still not certain how much course work is necessary nor how extensive a thesis should be. Have we raised the bar too high when we expect master's students to have publications and doctoral students to have even more of them? Canadian universities need to consider whether the research master's degree needs to be the typical entry requirement for the Ph.D. Universities will need to question the impact of new multidisciplinary programs on time to completion and how best to structure such programs. How should such programs be fitted into our present administrative frameworks? How can we be sure they create both disciplinary and multidisciplinary strength? What will motivate them? Will it be research clusters or funding opportunities?

If participation in a group positively influences retention, then funding agencies need to investigate the impact of graduate student funding mechanisms, such as training grants, that support involvement with others. New modalities will be needed for involving graduate students in the humanities in activities with other graduate students and researchers. In addition, mechanisms for setting objectives and tracking progress to degree need to be transparent and widely used. Advisors and administrators need to counsel certain students to withdraw earlier rather than later if they appear to be ill-suited to research and scholarship. Universities need to consider failing students for documented lack of research progress. Finally, issues of time to completion raise questions about the postdoctoral experience. Will shorter times to completion of a doctoral degree necessarily imply a postdoctoral experience? Will a postdoctoral scholar/scientist cost more than a graduate student? In the end will the time from the start of a degree to the start of employment be the same? These are all crucial questions for which we need good data.

Other Essential Elements in Graduate Studies

Professional Skill Training. More and more students and their universities are finding that it is an important part of graduate education to provide students with professional skill training over and above what they learn from their supervisors. They need the skills to present their research to various audiences, both in presentation and publication format. Graduate students and postdocs need to learn about and participate in research grant writing. Universities need to help graduate students find jobs both inside and outside of academia. This involves learning about the full range of employment possibilities as well as how to prepare a curriculum vita and interview for a job. The development of these career related skills implies the need for universities to provide graduate career counseling services.

Intellectual Property Rights and the Responsible Conduct of Research. Graduate students in Canada are actively concerned with their intellectual property rights all the way from the meaning of the copyright on their thesis to the marketing and proprietorship of a patent or the authorship of a journal article. In a time when universities are seeking out and developing research partnerships with non-university research partners, we need formal agreements that make explicit and transparent the rights and responsibilities of the student, the university supervisor and the non-university partner. Students need easy to understand guidebooks that explain their universities' intellectual property policies to them. Questions need to be raised about the meaning of non-disclosure agreements and their impact on students being able to share their findings with others, in publications and in university seminars. Should students be paid by their supervisors' spin-off companies? Can students use equipment in their supervisors' spin off company? Moreover, our students need to be taught explicitly about the responsible conduct of research. Students in professional degree programs take courses in professional ethics. Does your university offer courses in research ethics or a section of a research methodology course on human subjects' research and conflicts of interest? Mine does not.

The Postdoctoral Experience. There has been a recent growing interest in the postdoctoral experience. This interest has spawned a set of questions. Who will administer these important but often forgotten people on our campuses? How do we admit them? Is there a need for quality standards? Should they have to obtain, for example, a certain score on a TOEFL test? Are they paid a salary or a fellowship? Does this imply benefits or not? What are appropriate benefits? Is the postdoctoral experience a research internship or a job? Legal precedent in Quebec has determined that the postdoctoral experience is a research internship and not an employment category. If it is a research internship, then what are our educational responsibilities for postdocs?

Full Spectrum Science/Scholarship. In an exciting lecture sponsored by the Killam Trust at the 2002 Canadian Association for Graduate Studies conference, President Martha Piper from the University of British Columbia presented a rousing wake-up call to Canadian politicians and Deans of Graduate Studies concerning the importance of the humanities and social sciences in today's world. She cited evidence that cities with rich cultural communities and diverse populations are more successful in research and development. She reminded us that Canada, and I believe this could be extended to the United

States as well, have crucial roles to play in fostering the understanding of human culture and behavior. This understanding may well become the most important component of a global research and development agenda. Put succinctly, our graduates can invent all the widgets possible but if we cannot learn to live together peacefully these inventions may end up serving no purpose. One exciting outcome of Dr. Piper's lecture was the disproportionately high numbers of Canada Graduate Scholarships allocated to students in the social sciences and humanities.

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Some Final Links

In closing, I will mention three important links for us to consider.

First, it is important that university research and graduate studies administrators keep active links with each other and with their granting councils and governmental contacts.

Second, we need to foster the links and communication between humanities scholars, social scientists, physical scientists and life scientists. This world has many facets and educated citizens need to be aware of its multiple aspects.

Finally, this world also has many different countries and populations. We need to foster links between them so that we and our students can develop an understanding of multiple and diverse contexts for the creation of knowledge.

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RECRUITING AND TRAINING BUSINESS-SAVVY SCIENTISTS:

A REFLECTION ON THE CHANGING POLICY OF GRADUATE EDUCATION

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The business of science. To many it seems farfetched that science—especially basic research—and business are intimately inter-twined. Others bristle at the assertion that all forms of science should embrace business concepts. Even after the publicity surrounding *Prey* by Michael Crichton, bringing attention to the commercialization of nanotechnology, many continue to disregard the evidence that science and business are enjoying a renewed period of integration unmatched since the GI Bill redefined post-secondary education.

Consider, for example, the human genome project. What an amazing achievement. The publicly funded International Human Genome Project was started in 1990. But by 1998 only a small fraction of the three billion chemical letters had been spelled out. In May 1998, an upstart scientist, bankrolled by $300 million, formed Celera Genomics with the motto, "Speed matters. Discovery can't wait." A scant two years later, in June 2000 at a much-publicized White House event, the competition between the government-financed Human Genome Project and Celera Genomics was considered a tie—the two groups finished decoding the genome simultaneously. Or that was the story at the time. At the height of the competition Celera was able to raise $900 million in a stock offering. Many would assert that the competition between pure science and the commercial enterprise accelerated the achievement.[1]

On the business education side, there is a growing academic debate about the role of business schools as professional training academies[2] and the benefit/relevance of graduate business education to society in general.[3] The debate centers around the value of business education in the context of societal expectations and the motivation for changing a model that seems heavily influenced by constituencies with conflicting objectives. In this paper some of the issues will be discussed from a policy perspective with regard to science and business, as well as from a reflection on how graduate education expectations have changed over the past 25 years.

How is Graduate Education Changing?

For the public sector scientists of the Human Genome Project, who believed in an openly available genomic code as a guiding principle of the project, their work became accelerated and competitive. The basic research model changed to a time-dependent and outcome-focused activity with specific, or some would assert, strategic, goals. The human genome-mapping project began to develop distinct organizational mission, goals, overall strategy, execution processes, and program evaluation components. Perhaps more importantly, scientists realized that the achievement of their mission—public access to research results—would only occur if they became business-savvy.

Since the early 1980s there has been a growing sense of importance and complexity surrounding the development of basic research, including the opportunities to turn basic research into sources of revenue for universities. In 2000, universities collected over $1.1 billion in royalties from the 13,000 patents they hold. That same year the U.S. Patent and Trademark Office granted 3,272 patents to universities compared to 269 in 1979. Amazingly, Columbia University has received more that $200 million for permission to use one patented process for splicing human genes into living cells to produce human proteins, which are then turned into human drugs.[4]

How important are these numbers to the basic research program? Data from the National Science Foundation shows that over the last five years or so approximately 70 percent of basic research was conducted by universities that in turn led to research and development in commercial firms. However, of the research and development leading to new products, processes and services, industry activity accounts for approximately 70 percent of the publicly-recognized products and services. In fact, when comparing the division of innovation labor between universities and industry overall, a 90/10 pattern becomes evident. That is, only 10 percent of basic research is conducted by industry while universities conduct only 10 percent of innovation development.

In an effort to bridge this gap, the National Science Foundation developed and has continued to fund the Integrative Graduate Education and Research Traineeship Program (IGERT). This program seeks to take a multidisciplinary approach to train scientists and engineers, focusing on two identified needs:

1. facilitation of innovation, and
2. integrating business and external constraining forces, such as legal and regulatory mechanisms, into the development and advancement of innovation.

The IGERT program is now in its sixth year of funding.[5]

With these issues as a broad backdrop, the trends in university graduate education policy can be viewed as having experienced three rather distinct steps. Historically, the outcome of graduate education was expected to result in *education.* This changed around 1970 to a secondary outcome expectation; universities were expected to *educate and train* graduate students by imparting market-beneficial skills. The current expectations from graduate education include *education and integration*. That is, today graduating students are expected to have a broad multidisciplinary perspective *and* a narrow field of expertise. In common terms, we are expected to graduate students who can readily see the forest *and* the trees.[6]

What are the Linking Points to Graduate Education?

In the resource-dependent world of basic research, universities have turned to technology advancement in hopes of funding the business of science. Technology advancement includes the management of extramural funding for specific research initiatives hopefully leading to: innovation, innovation protection, and licensing and commercialization. While it would seem plausible that the latter would be the source of most business skills necessary to benefit the university, many argue that all facets of technology advancement benefit from the integration of business education.

To better visualize the science and business integration in the training of business-savvy scientists and engineers, consider a balance beam with *science* at one end and *business* at the other. At the first step of technology advancement, extramural funding and basic research, the balance beam is weighted heavily on the side of science. Yes, there are certainly business aspects to planning, budgeting, and expending resources with a particular research objective in mind. However, most graduate students and postdoctoral fellows have gained experience in these tasks that reflect the *education and training* expectations mentioned earlier.

The second phase, innovation recognition, characterized by the disclosure of a possible invention begins the questions: What do we have? What is it worth? Who will buy it? At this step, the balance beam is probably level. Market and financial analyses of invention value are conducted. Along with the search for “prior art,” scientists and innovation protection professionals are determining the potential uses and value of the invention.

In the final step, when decisions about licensing and commercialization options are made, the balance beam moves distinctly to the business side. Unfortunately, the steps occur in a rather disjointed manner because the lack of integration between science and business forces different groups to communicate in long and involved ways about the potential value of the innovation. In addition, the relative level of incentive alignment between the scientist and the university are de-coupled. For example, it is rare that a scientist has the personal or professional motivation to develop an in-depth understanding of the market for a particular invention much less the vehicles available for deriving value from the invention. It is much more common for the scientist to focus on publishing the results of the innovation since the majority of existing compensation links measure outcomes in terms of scholarly publication rather than application of the scholarship.[7] The following figure summarizes, in graphical form, some of the issues leading to the shift in the policy of graduate education.

What are the Policy Issues?

The policy issues for graduate education involve the need to train business-savvy scientists and revolve around two basic policy objectives:

- Imparting the skills that will make graduate students successful in industry, and
- Adapting to the changing roles and responsibilities of the university/industry research enterprise.

As the number of commercial enterprises with academic links continues to grow, problems associated with such organizations grow in direct proportion. There are at least four specific policy issues that must be acknowledged for the two policy objectives to occur. The policy issues of most importance seem to be:

1. developing appropriate university support services to assist in innovation value creation,
2. training scientists, engineers, and business students for commercial success in the fast-paced world of innovation advancement,
3. changing the risk/reward philosophy and alignment mechanisms in the university-industry environment, and
4. seeking to balance the capitalization of the research enterprise.

Developing Support Services. Many universities maintain offices of research and/or offices of technology transfer. Even more have established research foundations and commercialization vehicles. Most often these important functional units are somehow connected by interlocking employee duties. There exists a need for the development of integrated resource management processes to speed the flow of resources and assist in decision-making intended to assist the innovation creation, protection, and value generation. It would be a starting point, for example to simply adopt and adapt the resource management processes in place at technology firms such as Motorola, Phillips N.V., Proctor & Gamble, and many other firms that base their competitive advantage on continual innovation. In his recent work, Harvard Business School professor Henry Chesbrough suggests that “open innovation” is the model to be followed when redesigning the university innovation advancement process.[8] His contention is that innovation must be managed inside and outside the university/industry relationship since the most successful efforts, for example the Human Genome Project, seem to follow this model of cooperation and competition.

Training Graduate Students for Commercial Success. As the innovation enterprise described in the previous policy issue becomes a reality, there will increasingly be the need for capable people to participate in and manage the process. This places emphasis on the education and integration aspects of graduate education. It is important for scientists to understand the commercial processes just as it is important for business and law students to understand scientific inquiry, discovery disclosure, innovation protection, and licensing/commercialization processes. How does this begin? From a policy perspective it may occur at two levels. First, it may be initiated through the availability of funded graduate training opportunities, as exemplified by IGERT and similar programs. Second, and perhaps along a longer time line, is the development of multi-disciplinary teams of faculty and industry representatives operating in the open innovation model suggested by Chesbrough.

Changing the Reward Structure. From an academic standpoint, many of us recognize that peer-reviewed publication and extramural funding are strongly linked to desirable personal outcomes such as annual salary increases, reduced teaching responsibilities, additional resources, tenure, and promotion. Limited survey evidence shows that almost all research-focused commercial firms pay the inventor for patent filing, patent issuance, strategically important patents, and longevity in the patent "game." However, very few, if any, universities specifically reward inventors for these activities. Typically, universities share the royalties with the inventor after all the innovation value creation is completed—many times without significant involvement of the inventor. My own limited research into the relationship between telling someone what is important, developing a clear link to short term rewards for desirable behavior, and longevity in office (tenure) indicates that specific short term financial rewards, or as we call it—carefully coupled inventive alignment—overwhelms the simple effects of monitoring employee behavior.[9] How strong is the effect and how much incentive is necessary? Empirical research has shown that relatively small levels of incentive compensation result in aggressive changes in behavior. In industry, the typical award for patent filing is approximately $1000 with another $500 or so awarded upon patent issuance. Clearly, changing the reward structure at the university level is an important and far-reaching policy matter.

Balancing the Capital Needs. Perhaps one of the most basic facts about business is: Cash is king. That is, it takes cash to grow businesses of any type. This includes the innovation enterprise underlying the policy shift in graduate education. Capital needs can be grouped into two policy areas. First, there is the short-term need to establish funds to reward innovation creation and protection. Second, funds will be needed to pay for the infrastructure, staff, and start-up costs related to innovation value creation. Imagine the impact on the speed and effectiveness of innovation value creation if business-savvy scientists were involved in the advancement of their own innovation. As a policy matter, the allocation of extramural funding to pay for innovation creation must be balanced with the costs associated with innovation protection and value creation. Until now, most of the process has been loosely linked—the rousing successes are few and far-between. Changing the success rate will undoubtedly make a difference in how universities are able to change the nature and policies impacting graduate education.

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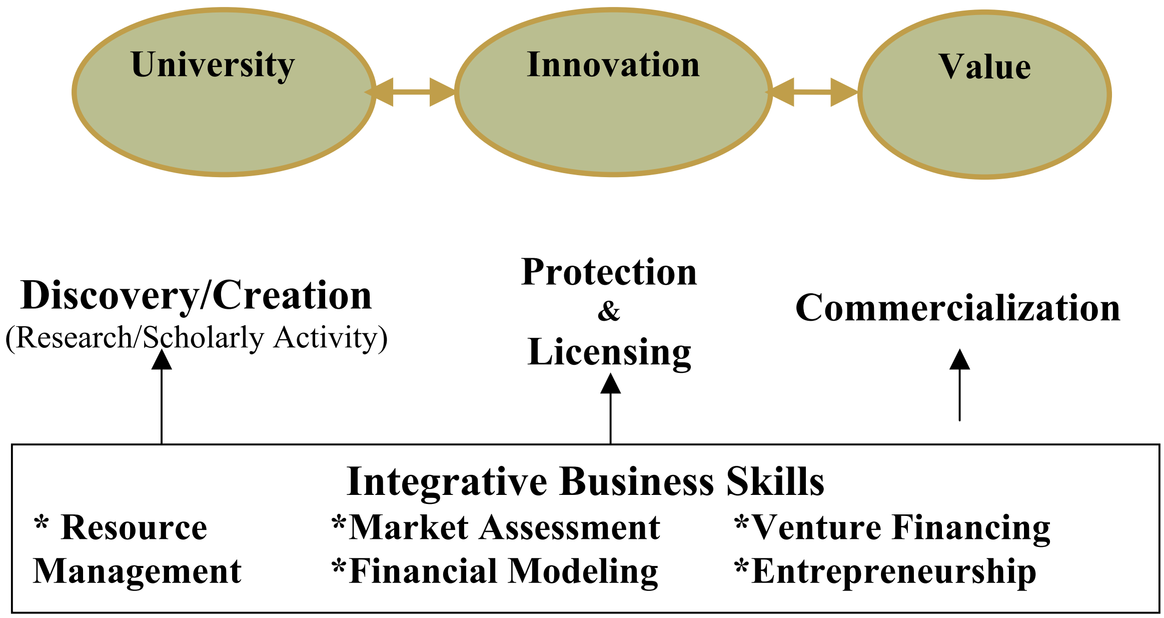
Technology Advancement & Business Education

Innovation Creation, Protection & Value Development



INTEGRATING RESEARCH AND EDUCATION:

MOVING FROM INDIVIDUAL FACULTY INITIATIVES TO INSTITUTIONALIZATION

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Introduction

An interesting transition occurs when you are tenured. You open your eyes after five years of focusing on your work, your teaching, your research and realize that you need to think about the health of not only your individual program, but of the department—and college and university. You know that your research program won't thrive without good students, solid teaching and cooperative colleagues. It is during this period that a faculty member starts to look outside her immediate interests and considers the needs of the institution around her.

Two components of a successful research program are funding and high-quality graduate students, and the two are often linked. In the last few years, the National Science Foundation (NSF) has re-emphasized the connection between education and research and the responsibility of researchers to be involved in both. Their guide to grant programs says:

> One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects and activities it supports at academic and research institutions.
>
> These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students, and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learning perspectives.

NSF requires that proposals address two separate merit criteria: one focuses on the intellectual merit of the work (Criterion 1) and the second asks the proposer to specify the "broader impacts" of the proposed work (Criterion 2). Proposals that do not separately address both of these criteria are returned without review. The emphasis on education and outreach is an explicit part of larger, group proposals such as Materials Research Science and Engineering Centers, but an education component is also required in the single-investigator proposals that are the mainstay funding for many researchers in math, science and engineering.

There are two major consequences of this emphasis. First, most faculty members have no training in what constitutes a good—or effective—education/outreach program. There are a lot of floundering scientists, mathematicians and engineers who are stuck when asked to specifically show how they are addressing "Criterion 2". The second issue is that the graduate students we are educating eventually will have to fulfill these requirements, so in addition to preparing them to do research (and write grants, and teach, and …), we have to give them the tools that will enable them to be competitive in the new arena.

Project Fulcrum, which is funded through NSF's GK-12 initiative, will be presented as a case study to emphasize two points: the enhancement of graduate student preparation through the involvement of graduate students in education and outreach programs, and how a program developed by individual faculty members can be institutionalized to benefit a wider group of faculty as they attempt to meet both of NSF's criteria.

Motivation for the GK-12 Program

The state of K-12 science and mathematics education has received a lot of attention due to increased accountability, decreased numbers of students entering math and science careers and decreased science literacy.[1,2] K-12 school systems must address the needs of an increasingly diverse population while meeting national and state standards[3,4] and developing assessments—all with diminishing resources.

NSF introduced the Graduate Teaching Fellows in K-12 Schools (GK-12) program in 1999 to produce scientific research leaders who are aware of and sympathetic to the challenges facing K-12 education. Graduates of this program will support the continued involvement of scientists, mathematicians and engineers in K-12 education in the future and will be in a position to understand how to most effectively participate. GK-12 awards primarily fund graduate student fellowships (with the same stipend as NSF research fellowships), plus some funding for teachers and administrative structure. While the program has a much broader focus—the goals include improving math and science education, building partnerships between universities and schools districts, and providing resources to teachers—the idea that the graduate students are the focus is the key.

Project Fulcrum Details

The University of Nebraska was awarded a GK-12 grant in 2001 to Principal Investigators Diandra Leslie-Pelecky (Physics), Gayle A. Buck

(Teaching, Learning and Teacher Education), Sue Kirby (Teacher, Clinton Elementary School), Roger D. Kirby (Chair, Physics) and Patrick Dussault (Chair, Chemistry). The project was named Project Fulcrum in honor of a quote from Archimedes: "Give me a long enough lever and a place to stand and I can move the Earth."

Project Fulcrum is a collaboration between the College of Arts and Sciences and the College of Education and Human Sciences, in cooperation with the Lincoln Public Schools. Thirty graduate Fellows over three years will serve as resources for elementary or middle schools. Fellows partner with a lead teacher at the school to develop efforts that address that school's particular needs. Those ideas are used as a platform for the Fellow to reach out to other teachers and classrooms. In 2002-2003, graduate Fellows worked with 10 Lead Teachers, 37 additional "cooperating" teachers and over 2,300 students.

GK-12 Fellow stipends are the same as NSF Research Fellowships ($27,500/year for 2003-2004, plus a $10,500 cost of education allowance). Fellows spend 8 hours per week in the schools working with teachers and students, 2 hours per week planning with teachers, and up to five additional hours in preparation. The time required is comparable to a teaching assistantship. Prior to entering the schools, Fellows and their Lead Teachers have a one-week Summer Institute where the Fellows learn about education and the specific issues we want to address in the schools, partnerships are formed and strengthened, and the initial planning is accomplished.

Lincoln Public Schools (LPS) is an urban district serving 32,000 students. An extensive self-analysis based on recent student achievement data led LPS to identify grades 4-9 (and particularly 6-8) as targets for improving student achievement. LPS historically is a high-achieving school district, but while elementary-grade student achievement in math/science has advanced in the last 5 years, middle-level achievement has remained relatively stable and behind elementary level achievement. This reflects a national trend of poor performance of U.S. middle level students when judged against international competition.[5] In addition, girls' interest in math and science decreases significantly in these grades compared to boys' interest.[6] LPS has developed a No Child Left Behind Middle Level Plan focusing on improving math and science achievement and narrowing the achievement gap for ethnic minority and low-income students. We meet LPS needs by working primarily in middle schools plus a limited number of elementary schools that feed into the targeted middle schools, and addressing achievement gaps in at-risk populations.

Goals

NSF's request for proposals was very explicit: In addition to goals for the graduate Fellows, teachers, and students, they wanted GK-12 programs to impact the institutions involved. The fourth and fifth rows of Table 1 illustrate

Project Fulcrum's infrastructure goals. This requirement is one of the elements that encourage individual faculty members to look beyond their own interests to how they can influence the priorities and programs of the institution.

Table 1: Project Fulcrum goals	
Fellows	(1) Understanding how scientists and mathematicians can help address K-12 education challenges, (2) Improved communication skills, especially with non-scientists, (3) Early exposure to educational research and the professional education community, (4) Develop abilities to continue working with K-12 outside the project.
K-12 Students	(1) Increased science and math understanding, (2) Increased experience with inquiry, leading to facility with the scientific method, (3) Appreciation for the relevance and applicability of science, (4) Exposure to diverse role models, (5) Increased self-confidence and interest in science.
Teachers	(1) Increased teacher comfort with science and math content, (2) Increased understanding of the design and assessment of inquiry-based instruction, (3) Improved working relationship with the university and university personnel,[2,5] (4) Development of leadership skills.
LPS	(1) Enhanced in-service opportunities for all teachers, (2) Establishment of a community that discusses and advocates for science education, (3) Closer linkage with the University.
UNL	(1) Improved cooperation between the College of Arts & Sciences and the College of Education and Human Sciences (formerly Teachers' College), (2) Increased exposure of faculty scientists to the Lincoln Public Schools and the impact of standards; (3) Increased faculty interest in teacher education.

Outcomes

The outcomes from the first two years of Project Fulcrum are shown in Table 2. The outcomes for teachers and student were very favorable, but the comments in this section will focus on the impact of the program on the graduate Fellows, faculty members, and the institution.

Impact on Graduate Students

The primary impact of graduate Fellows in elementary and middle schools is that the Fellows are walking examples of the scientific method. The graduate students model the scientific process, have the confidence to jump into a problem they don't already know the answer to, and excel at troubleshooting everything from computers to lab equipment. Teachers appreciate having a ready resource for content questions. In many cases, the Fellow may not know the answer off hand, but does know where to find the answer quickly.

Our external evaluators found that the opportunity to form collaborations with people from other departments greatly enriches the Fellows' experience. Mentoring received through the program is especially important for students who will do a coursework Master's degree and those students who have not yet found a thesis advisor. This support network of project management and participants is especially important for those women who are significant minorities in their home departments.

The benefits are not only in the personal arena. We have at least one example where two Project Fulcrum graduate Fellows in disparate fields started a joint research project that would not have happened without their involvement in Project Fulcrum. Our external evaluation showed that, while Fellows identified themselves with Project Fulcrum, their participation did not adversely affect the graduate students' progress or sense of "belonging" in their home departments.

Our Fellows felt that their communication abilities—especially with non-scientists—were greatly improved through their participation in the program. Although there was a lot of frustration in the beginning as Fellows learned to communicate with each other, teachers and students, the Fellows were proud that they recognized how to adapt their communication patterns so that they would be effective in different environments.

Table 2: Project Fulcrum Outcomes 2001-2003	
Fellows	• Have greater appreciation for the challenges of K-12 education, especially classroom management and the impact of the standards. • Feel they have improved their ability to work and communicate with people from diverse backgrounds. • Feel they made a significant difference in their schools, although their impact was less than they originally expected. • Formed collaborative groups to address special projects such as science fairs. • Intend to continue working with K-12 teachers and/or students.
Teachers	• Find that Fellows are flexible enough to meet their schools' specific needs. • Feel more comfortable making use of university resources (including scientists). • Are more comfortable with their teaching ability and knowledge of science. • Liked having a community of science/math educators within Lincoln Public Schools (LPS). • Recognize the importance of involving many teachers within their school if systemic change is to be sustained.

Table 2: Project Fulcrum Outcomes 2001-2003	
Students	• Show greater enthusiasm for math and science. • General learning efficacy and math efficacy improved at all middle schools; however, preliminary results show that science efficacy remained constant at two middle schools and decreased at the third. • Student images of scientists significantly improved at two middle schools. Images at the third significantly increased for females, but decreased for males. • At the midterm, image of a scientist, general learning efficacy, general learning attitude, math efficacy, math attitude, science efficacy and science attitude all improved in the elementary schools.
UNL and LPS	• The Principal Investigator (PI) was invited to give colloquia in biological sciences and physics at UNL, which increased campus awareness of Project Fulcrum and broadened the graduate student applicant pool. • More UNL faculty and graduate students volunteered to visit K-12 schools. • UNL and the Lincoln Public Schools reward faculty for participation: The PI was tenured last year, in part due to the success of Project Fulcrum. Co-PI S. Kirby has been nominated by her principal for Nebraska Teacher of the Year. • UNL's College of Arts & Sciences has changed faculty effort assignments from the traditional three categories of research, teaching and service to five categories: research, teaching, service, outreach and administration.
Infrastructure	• A formalized framework for the project is in place. • Developed a Summer Institute preparation program for Fellows and Lead Teachers, including a web-based handbook. • Developed a web-based data entry and analysis system. • Establishment of a permanent Project Fulcrum Office (provided by a severely space-strapped Physics Department). • Inclusion of experiments and activities from the PI's previous outreach program. • Participants have given talks/workshops at meetings of the American Physical Society, National Association of Research in Science Teaching, Nebraska Science Teachers Association, Nebraska Educational Technology Association, and National Association of Science Teachers, plus seven invited colloquia at universities and colleges across the country over the last two years.

Impact on Faculty

The faculty coordinating Project Fulcrum get more than summer salary and a good feeling for helping to improve K-12 science education. This project provides many opportunities for research into how scientists can be most effective in the K-12 classroom. We have found that many of our preconceptions—such as believing that putting women scientists in the classroom changes student's stereotypes about scientists—are wrong. The pilot project for our GK12 proposal serves as a good example. Three women graduate students worked with 4^{th} and 5^{th} graders on an electricity and magnetism unit. We consulted with the teachers to determine how to best fulfill their goals, brought lots of equipment and activities for the students to do, and made sure that we were using terms and explanations appropriate to the children's' ages. We even made a video of one of the Fellows in the lab, explaining what she did and the equipment she uses.

Four weeks into the project, interviews with the children showed that they didn't recognize that the women in the classroom were scientists. Student stereotypes were already so strong that the women scientists not only didn't break the stereotypes, they were excluded from being scientists in the minds of the students. The questions we planned on asking about their stereotypes of scientists and how the presence of the women affected these stereotypes could not be addressed because our basic presumption about the project was wrong. This also serves to illustrate the benefits of scientists working with their colleagues in the Education College; few scientists would think to ask whether the kids realized that their visitors were scientists. Without asking these questions, we would have completed the eight weeks, stood back to admire our work, and left, never realizing that we didn't have any impact on the students' stereotypes about scientists.

Impact on the Institution

Project Fulcrum is a good example of how a project progress with time. We had a difficult time recruiting students during our first year. As the program continued, the publicity it attracted (especially the magnitude of the stipends) drew the attention of students in disciplines we hadn't thought to involve (such as engineering). In 2003-2004, we had 2.5 applicants for each position and had to turn down many very talented students. The growing participation across departments, as shown in Figure 1, increases the potential for campus-wide impact as we develop a reputation as a successful program. The PIs have been invited to give talks in a number of science departments and those talks have drawn a surprising number of volunteers from the campus community.

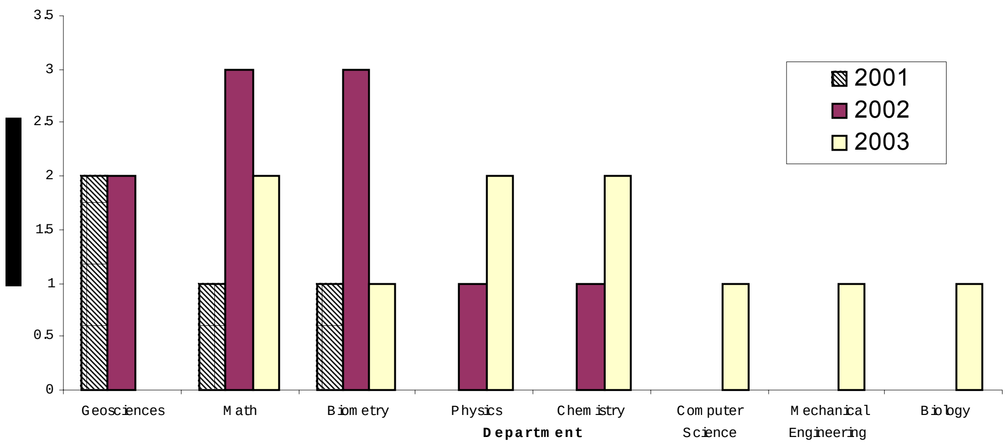

Figure 1: Representation of departments in Project Fulcrum 2001-2003.

A second aspect of the institutional impact is the ability to raise campus-wide attention about the climate for women in science, math and engineering. Our participants are overwhelmingly female (Figure 2). Each year, the percentage of women has been greater than 60%. While not unusual for the population as a whole, the availability of women in the pool of graduate students is approximately 25%. This encourages discussions about the impact of gender in science education at both the K-12 and the graduate level.

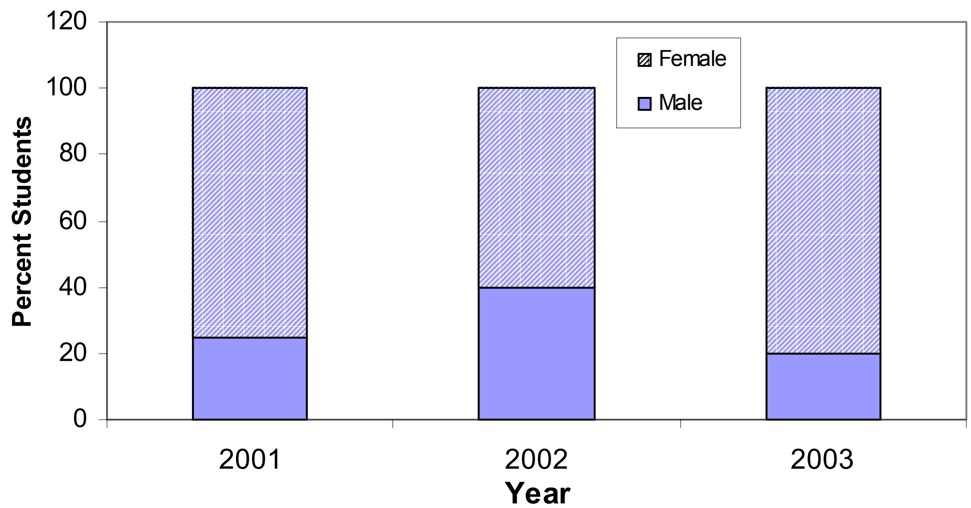

Figure 2: Male and Female participants in Project Fulcrum 2001-2003.

It is important to note that Project Fulcrum does not exist in a vacuum at the University of Nebraska. We have a broad variety of math and science education programs that involve many science, math and engineering faculty. We have mounted several initiatives for large multidisciplinary projects. The preparation of future math and science teachers has been identified as an academic priority. Project Fulcrum has both benefited from and strengthened this community.

Project Fulcrum has developed contacts with the school district and—probably more importantly—with individual teachers and their principals. At this point, we have a cadre of teachers comfortable working with scientists. We have a better idea of what types of projects and activities work in the classroom, the potential impact of the Fellows in the school, and the impact of the program on the Fellows. Tangible items, such as a collection of materials that can be checked out and a central office, have helped to give brick and mortar infrastructure to the project. While there is much left to do, we believe that we can call the project—thus far—a success.

Why Institutionalization?

Invitations to submit Track 2 GK-12 grants were issued in 2001. Originally, GK-12 grants were to be one-time awards; however, the data showed that a wealth of information about how scientists interact with K-12 schools offered great promise for further studies. This type of information is exceptionally necessary; a graduate Fellow in a classroom needs to make an impact and that impact needs to be documented. Track 2 grants require programs to use the knowledge they've gained during their first grant to go beyond just executing a program. The goal is to use prior experience to make institutional changes that will continue past the funding period of the grant. This requirement is strong encouragement to faculty to think about the relationship of their program to the institution as a larger entity.

Return again to the changing role of the faculty member as proposal writer. Professor X is joining a science department this fall, and one of the first things she must do is write a grant to request NSF funding for her research. Professor X is interested in working with middle schools, so she needs to identify schools and willing teachers, get permission from everyone involved, develop activities and execute them. One-time visits with "gee-whiz" demonstrations may increase student enthusiasm for a short time; however, most faculty members simply don't have the time to engage in extensive advance planning with the teacher to ensure that their demonstrations meet the goals the teachers need to address that day. Professor X doesn't want to make outreach her career. She wants to propose something that is good enough to get the grant, can be carried out with minimal time and energy, and—most importantly—makes a difference. The NSF mandate for institutionalization has important implications for faculty members. How do we enact change at the university level? In the case of Project Fulcrum, shouldn't there be some way to use what we have established to prevent Professor X (and Professor Y and Professor Z) from having to re-invent the wheel?

Why not use the infrastructure developed by Project Fulcrum to give Professor X a head start? Project Fulcrum already has the contacts with the school district and teachers. We have a pretty good idea of what works, and the materials for these activities are collected, have been designed to be easy to transport, and are maintained. Professor X should be able to leverage what's already been done to propose something that can be done with minimal effort, but that makes a difference in K-12 education.

Institutionalization of the Project Fulcrum infrastructure is the education/outreach equivalent of "tech transfer." Developments in one area are leveraged by others. A faculty member is generally not interested in taking time off from his teaching and research to run such a program, so this is where the institution can play a major role. Establishing a central office responsible for providing logistical support—matching teachers and faculty members, arranging times and equipment, etc., is more efficient than each faculty member doing his or her own coordination. The role of the institution need only be as caretaker: to preserve the elements of the program that were developed during the funding period. The institution could, of course, also contribute to the growth of the infrastructure where possible or desired.

What does the institution get out of it? Faculty members don't spend a significant amount of time doing things they don't have much experience doing, especially those that may already have been developed. These faculty members are likely to have a better education component to their proposals, which can improve the chances of funding. Once funding is secured, the faculty member spends less time, but still makes a large impact. The evidence from all of the GK-12 programs is that the participating graduate Fellows significantly improve their "people skills" and leave the program with a very different attitude about their responsibility toward K-12 education. Research innovation may pay off for universities in terms of patents and publicity; however, institutionalized education and outreach initiatives have the potential to make a big difference in terms of the quality of graduate (and undergraduate) education, the preparation of graduate students for future careers, and the success of the faculty in obtaining grants.

VICTIM OF SUCCESS:

A DISCIPLINARY CASE STUDY

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Higher education is traditionally organized along disciplinary lines, with departments and programs generally corresponding to individual disciplines. Like most entities, disciplines have their own life cycles, marked by periods of growth, changes in societal attention, and the waxing and waning of student interest. This paper describes the changes in one discipline, communication sciences and disorders, during the past century and the delineation of some of the lessons those changes offer to other disciplines.

Communication sciences and disorders (CSD) has several attributes that make it a good entity for study. First, it is one of the oldest disciplines, with roots going back to the ancient Greeks. Demosthenes, who filled his mouth with pebbles and taught himself to speak clearly over the sounds of the sea, reflects the value that we have placed on clear and effective communication from the earliest of times. Second, the field bridges both basic and applied research. In CSD, experimentation in neuromotor control systems, inner ear hair cell regeneration, and early language development, support applied research in a range of diagnostic and treatment strategies for those with communication disorders. Third, the field is well represented in the academy, with more than 250 graduate programs across the U.S.

The 20th Century

Early in the last century, those working in the field began to formally organize themselves as a discipline to increase their effectiveness and their professional visibility. These individuals came from the field's roots in elocution and were joined by psychologists interested in the phenomenon of stuttering, physicians studying brain damage and aphasia, and educators working with schoolchildren who had difficulty speaking, and others. From initial gatherings of interested individuals, the discipline was formalized in 1925, when the predecessor of the American Speech-Language-Hearing Association (ASHA) was founded.

The minutes of the first meeting of that association make it clear that the focus of the organization was to be scientific:

> "…this organization shall have as its purpose the promotion of scientific, organized work in the field of speech correction" (Malone, 1999).

The Association's constitution, adopted one year later in 1926, amplified this focus by stating that the association was to:

- "stimulate…more intelligent interest in the problems of speech correction";
- raise the standards and the visibility of the profession;
- and create leadership for the profession through respect of good works "i.e., by our scholarly research work, publicity work, and administrative skill."

This focus on science and research reflected both the interests and the aspirations of the discipline's early leaders, for they believed that only through scientific exploration would they be able to assist those with communication needs.

In the decades following its founding, the discipline focus remained on research, and universities became the locus of that activity. But following World War II, there were increasing pressures to respond to the clinical needs of society. Veterans returning from the war put significant demands on the medical and rehabilitation resources of the nation; in fact, the creation of the profession of audiology was largely a response to those needs. Later in the century, the field expanded beyond speech and hearing to formally recognize the mediating role of language in the communication process. This recognition, in turn, led to professional responsibility for a host of new communication problems in individuals of all ages. At the same time, the federal government recognized the rights of all children to receive all needed supportive services. The Individuals with Disabilities Education Act (IDEA) and the Americans with Disabilities Act (ADA) put into law our national commitment to the rights of all citizens; with that legislation, the demand for speech and hearing professionals grew.

The discipline responded to these increased demands for service in laudable ways. In 1965, for example, the Association adopted national certification standards for speech-language pathologists and audiologists. These standards required completion of at least a master's degree prior to certification and specified the academic and clinical experiences necessary for entry into the professions. The Association also took responsibility for creating and implementing accreditation standards for educational institutions. Given the designation of the master's degree as the entry-level credential, these accreditation standards understandably focused on Master's curricula; and in fact, undergraduate and doctoral curricula were generally viewed as outside the purview of the accrediting body. It is important to note that these steps marked ASHA as extremely progressive. Many other fields have only recently begun moving to advanced training as a prerequisite to clinical certification. Communication sciences and disorders, however, decided early on to set a high standard for training in order to assure the best possible clinical services for the public. At the same time, however, it set in motion a trajectory that put the entire discipline at risk.

The clinical certification standards set by the discipline were challenging but attainable. During the past 50 years, ASHA membership has soared to over 100,000 members (Table 1.) In 1951, the majority of the Association's 1,859 members were academicians interested in the study of communication processes and its disorders. In 2003, the vast majority of the membership is comprised of clinical professionals, holding what is for all intents and purposes terminal Master's degrees. As a result, the field now has a much stronger identification with the professions of speech-language pathology and audiology than with the discipline of communication sciences and disorders. This is true in society, at large, where the impact of 100,000 practitioners can't be ignored, and within the academy, where many departments focus on clinical instruction.

Table 1. Membership in the American Speech Language-Hearing Association, 1951 - 2003

Year	Members
1951	1,859
1961	7,587
1971	13,741
1981	34,772
1991	61,168
2003	103,000

One of the effects of the early move toward Master's-level certification and accreditation is that the undergraduate and doctoral curricula in the field began to be defined relative to the master's curriculum. Unlike other fields where undergraduate, Master's, doctoral, and postdoctoral work form a progression of study moving a student further into the details of a particular aspect of the field, the undergraduate and Master's curricula in communication sciences and disorders (CSD) serve primarily to prepare individuals as service providers. Those students pursuing a research career follow these initial six years of training with the challenge of starting over in their education to acquire the specific knowledge and scientific skills necessary for a doctoral education. Formulating a curriculum around the master's degree also had an effect on the type of students who were attracted to the field, with an ever-increasing number of students who had little or no interest in the science of the discipline. Students were drawn to the field by a respected professional credential, guaranteed employment, and a good salary (entry-level Master's salaries remain competitive with those of doctoral faculty at many universities). Ironically, the very steps taken to assure a science-based profession (Master's requirement, national certification standards, academic accreditation programs), led to an academic environment in many departments that reflected a diminishing scientific focus.

Today, there are over 250 graduate programs in communication sciences and disorders in the U.S. with 61 of those offering the Ph.D. (Shinn, et al., 2001). At the same time, there are nearly 10 times as many students enrolled in Master's programs as Ph.D. programs (Table 2.) As a result, most doctoral programs have exceedingly small enrollments. Of the 61 doctoral programs in the country, 40 have fewer than 15 students and only four have at least 25 students. This relative dearth of doctoral students does not bode well for the future of the discipline and its likelihood for replenishing and expanding future faculty (Oller, Scott, & Goldstein, 2002). Moreover, the size of the individual student bodies combined with the number of sub-disciplines within the field means that few CSD doctoral students are working in a cohort of like-minded junior scholars, something that is recognized as a valuable part of the doctoral experience.

Table 2. U.S. enrollment in communication sciences and disorders in 2001

Level	Enrollment
Undergraduate	16,397
Master's	7,389
Ph.D.	795

Response to the Crisis

In response to the impending crisis in the discipline, the American Speech-Language-Hearing Association and the Council of Academic Programs in Communication Sciences and Disorders (CAPCSD) appointed a joint committee to develop a plan to:

- increase the number of doctoral students in communication sciences and disorders;
- retain current doctoral faculty;
- develop strategies for educating students in communication sciences and disorders in the current climate of doctoral shortages.

Appointing a committee is not altogether surprising; in academe, when you're faced with a problem—form a committee! A couple of aspects are noteworthy, however. First, its formation marked a serious discipline-wide effort to address a serious problem. ASHA had evolved into a largely professional organization with the delivery of professional services as its primary role. The Council of Academic Programs had a membership comprised solely of academic programs and was created in the mid-70's, in part, to give voice to non-clinical concerns. Thus, the formation of a joint committee reflected a coming together of the two halves of the field. Second, the group was not charged with addressing the problem, but rather with creating *a plan* for addressing the problem. This charge reflected a history of well-intended efforts that had been limited in their effectiveness, and the awareness that a coordinated effort was the only strategy that could succeed. Third, the recommendations that resulted from the committee's work did not focus on external remedies, but instead focused inward and especially on the culture of the academic departments within the discipline. Unlike the product of many academic committees, few of this group's 30 recommendations called for increased spending as a means of addressing the problem. Instead, many of the recommendations called for a change in how academic departments operate. (ASHA-CAPCSD, 2002)

Prognosis for Success

On balance, the prognosis for success for the discipline is guarded. The importance of re-invigorating the science of the discipline has finally gained a wide appreciation and has motivated an unprecedented level of cooperation among individuals and groups within communication sciences and disorders. At the same time, the field is facing a monumental task. First, it is attempting to reverse a decades long trend toward the professionalization of the field and continuing societal pressures in that direction. Second, it is fighting significant inertia within the academy. Hundreds of departments across the country have configured themselves around a set of assumptions that need to be re-examined and modified. These assumptions range from the nature and interests of the students, to the underlying tenets of the curriculum, to a department's role in its university. Academic departments typically change slowly and even then they do so in their own way. To move all, or even most of these departments in a similar direction in a reasonable period of time will be a challenge. Third, the nearly 300 CSD departments nationwide reflect a diversity nearly as large as higher education itself. CSD departments are found in colleges of liberal arts, allied health, medicine, education, communication, and others. Thus, each faces its own set of particular challenges and must meet differing institutional expectations for performance. Implementing the several recommendations of the Joint Ad Hoc Committee will be much more difficult for some departments than others, given differing institutional expectations and resources. Fourth, while there is consensus on the need to redefine ourselves, there is not unanimity. Some individuals are less convinced than others that the field should take any step(s) that would de-emphasize its professional image. This feeling is more widely held outside of the academy than inside, but the feeling exists to some extent in all circles.

Lessons Learned

There are several potentially valuable lessons to be learned from the experiences of CSD over the past century. Many of these concern the need for maintaining a balance between the discipline and the profession(s) of a field. A discipline is a *branch of knowledge or teaching* (Morris, 1970) and the founders of the field of communication sciences and disorders were interested in defining just such a branch of knowledge (from minutes of the organizational meeting in 1925: "…this organization shall have as its purpose the promotion of scientific, organized work in the field of speech correction"). A profession, by contrast, is *an occupation or vocation requiring training in the liberal arts or the sciences and advanced study in a specialized field*. The establishment of a master's degree as the entry-level credential for clinical professionals, was wholly consistent with this definition. As the demand for trained professionals grew, however, the field was unable to provide sufficient resources to meet that demand while at the same time maintaining the branch of knowledge that was the discipline. Simply put, immediate societal pressures overwhelmed longer-term scientific needs. This imbalance between the professions and the discipline had several effects, including a concomitant imbalance of applied versus basic research and of responsiveness to external versus internal constituencies. As the field moved further from its disciplinary focus, it also moved further away from an academic focus. This exacerbated the disconnect between the field and its liberal arts traditions and led to its marginalization in some universities. As part of the same reinforcing spiral, the leadership of the field became increasingly influenced by, and drawn from, the professions. Thus, at the highest levels, it was difficult to exert the influence necessary to maintain balance in the field. Maintaining such a balance will always be difficult in a field like CSD, because the number of scientists will likely never again approach the number of clinicians. At the same time, the field has a huge stake in those relatively few scientists and this must be respected if the field is to survive.

There are two other lessons that can be learned from CSD. First, disciplines should stay alert to periods of rapid change. Clearly the 1960's and 1970's were marked by a whirlwind of changes in communication sciences and disorders. A more than 400% increase in membership, the establishment of professional credentials, and claiming the authority to set academic standards are but a few of the markers of the changes that were underway. The challenge for any field going through such change is to recognize its magnitude and to remain objective about the motivations and the effects of the change. In the case of CSD, the external motivations for service to society and the positive feedback generated by providing this service, blinded the field to the other, less desirable, impacts. Second, disciplines are human enterprises that are defined and maintained by individuals working independently and in organized groups. Thus, the importance of individual leadership is crucial to maintaining the disciplinary balance described above. Through the latter part of the 1900's there were voices calling for a re-commitment to the science base of the discipline (Bernthal & Mendel, 2000; Hochberg, 1996; Minifie, 1997; Ringel,1982; Schiefelbusch, 1981, 1991; Wilcox, 1998), but these calls went largely unheeded. The discipline failed to provide these ideas with the attention that they deserved. By contrast, the creation of the Joint Ad Hoc Committee in 2001 was the result of the right combination of leaders emerging at the same time in both the American Speech-Language-Hearing Association and the Council of Academic Programs in Communication Sciences and Disorders. These leaders had an appreciation for the issues, and the willingness to lead an effort to address them. The simple lesson for professional associations is that they must stay attentive to the long-term well being of the discipline and balance future needs with short-term agendas.

As we enter the 21st Century and the era of the "knowledge economy," there is a growing demand for advanced technical training in a range of fields. Just like communication sciences and disorders in the middle of the last century, other disciplines (e.g. biology, chemistry, engineering) are presently experiencing an increased demand for persons with master's degrees who can help to address the technical needs of society. Indeed, in a 1995 article in the *Chronicle of Higher Education*, Anne Petersen, deputy director of the National Science Foundation suggested that "The Ph.D. should be construed in our society more like the law degree. A lot of people go to law school with no plans to practice law." Many university departments are rushing to fill the growing demand for science practitioners by creating new curricula, changing admissions philosophies, and redefining faculty roles; and in most cases these departments are being rewarded for their responsiveness by their institutional leaders and by the private sector. While it may sound extreme to envision the field of biology becoming dominated by practitioners, the same feeling was likely held by many of the 1,859 members of ASHA in 1951. It is difficult to predict what the next 50 years might bring. All science-based disciplines, and especially those with increasing demands to serve society may be well advised to heed the lessons of communication sciences and disorders.

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REACTION AND CONFERENCE SUMMARY

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One of the keystones of this conference came from the man to whom I will refer to as our "elder"—Richard Schiefelbusch. At one point, he said quite simply "I think we have to go a little further." Indeed, this conference has been about moving our graduate studies and research enterprise a little further and I think it did much to move our thoughts further along.

In our hands we hold a great responsibility. During the conference Ellen Weissinger told me that when professors are tenured at her university, the provost tells them: "Our university is committing to you for life and we think so highly of you that we are committing generations of students to you." In Canada and the United States, graduate deans and vice presidents of research are responsible for close to 2 million graduate students and the scientific and scholarly futures of our two nations. This is a daunting responsibility. Robert Barnhill reminded us that our role is to see to the mentorship of those 2 million students, assuming the role of Odysseus' trusted counselor, under whose disguise Athena became the guardian and teacher of Telemachus. Debra Stewart likened us to Janus, the two faced god, simultaneously protecting those we are responsible for as well as searching out opportunities for them. It is our responsibility to help our graduate students attain a range of what John Colombo called "competencies," or as Mabel Rice put it: "Our goal is to create effective researchers who will help us acquire new knowledge." This is a sizable goal by any measure. It is a goal that will take not only us, but also our nations and society in general, a little further.

In moving forward, we need to understand ourselves better. We need to collect the same high quality data and analyze it, as we would do in our own disciplinary research endeavors. Facts can be transformative and we can capture our transformations in facts. Robert Barnhill showed us growth and investment charts that capture the recent transformations in research at KU. Comparative data helps to awaken us to our own local realities. I talked about the transformative effect of showing cross-university student retention data to the faculty at McGill University. However, both Debra Stewart and I acknowledged that it is not easy to get the facts straight. It is difficult to agree on definitions and taxonomies, and this difficulty will only increase as the nature of our graduate programs evolve beyond the classical disciplines with their well understood nomenclature.

Increasing importance is being given to multidisciplinary programs. The ability to educate our students to work and do research at the interface of disciplines certainly has the potential to enrich our knowledge. But it will be necessary as we move forward to make sure that multidisciplinarity is not simply a buzzword or a popular educational fad. We need to ask ourselves whether such programs are for all fields or for all students. It will be important to determine how to implement these programs in our universities in ways that are highly flexible and adaptive and in ways that avoid turf wars between departments and deans. Every institution has a different matrix of governance and it will be up to each institution to determine what arrangement for these programs best fits its own particular configuration.

I have an Inuit friend who lives in the far north of Canada. She once said to me that for her, television was like a periscope; it helped her to see what we, the other North Americans, are up to. This conference has provided me with a kind of periscope onto the graduate studies and research situation of the United States. I find it unusual to be looking across the border and finding that my American colleagues are going through difficult economic times. Such difficult times are a phenomenon that many Canadian academics thought was reserved only for our institutions. As an American Canadian I find myself empathetic to your situation. Straddling the borders as I do has perhaps given me an insider-outsider perspective from which to comment on what I see and hear about higher education in the United States at this time.

Once again, Richard Shiefelbusch summed it up nicely when he said, "We are in a bit of a crisis." In Canada, we are just emerging from a period of very deep budget cuts in our universities. We need to ask ourselves how ordinary people make it through hard times. How do they effectively deal when there is less to go around? Unless they are in denial or blindly optimistic, people in a time of need do not usually carry on as though nothing has happened. Instead, they share what they have with each other. They become more collaborative and they have to make choices. Universities need to be strategic in difficult economic times. They need to leverage funds and to become enterprising. We have heard interesting examples of such initiatives at his conference. We have spoken of initiatives such as partnering with the private sector, of marketing goods produced on our campuses, of encouraging granting agencies to increase funding to graduate students, and using laboratory space in the private sector for graduate students. People can manage amazingly well with relatively little. Perhaps, it is the Scottish heritage of my university that makes us work so hard on leveraging external funds. One small example of this is how we decided to assign operating funds in the form of fellowships to graduate students. Our operating funds are allocated to programs that have already been successful in attracting external fellowship money for their students. It is somewhat like a card game that my children play in which the rich get richer. This allocation formula serves as a reminder to the community that we must leverage external money and that university funds will be allocated to meritorious programs.

Yet, being in difficult times also has very real dangers associated with it. It can push people into positions where they become desperate. This, in turn, can lead to regrettable partnerships and behavior. Richard Schiefelbusch told some of us that in his career, he had certain values that he felt it was important to uphold. The questions universities need to ask include: How far out on the edge can we go? What are our fundamental values? What will we uphold in our universities no matter what happens? I once arranged for Graham Bell, one of our preeminent scientists at McGill, to talk to a group of our top graduate students at McGill. He told the group about how some of the most important discoveries in biology have happened by accident in university laboratories where scientists were playfully experimenting. It is important to preserve the university as a place where such playfulness and free ranging thought can continue to exist. When research is only goal oriented, we are likely to lose something. Trying the ridiculous sometimes leads to finding the miraculous. One of the fundamental values of the university is that it is a protected environment in which our scientists and scholars have the freedom to think in unfettered ways. Kim Wilcox said it well when he told us that partnering with others is a question of balance.

We also discussed the societal situation of universities at this conference, asking ourselves, among other things, how we can change people's perceptions of graduate studies and research. Suzanne Ortega reminded us that universities cannot change in a vacuum, divorced from change in the society around them. Changing societal attitudes toward science and scholarship is important to the future of both research and graduate studies. I learned recently that 70% of Americans do not understand basic science. A recent survey reported that when Canadians, Americans and Europeans were asked if ordinary tomatoes had genes or if only genetically modified tomatoes had genes, the vast majority responded that ordinary tomatoes did not have genes. Diandre Leslie-Pelecky described for us a fine example of how she, as a physicist, had joined forces with a professor in education to change the attitudes that children in Kindergarten through 12th grade had about science and about pursuing scientific careers. The children were startled to learn that scientists could be pretty and could talk in ways that they understood. What and how we communicate to the public is clearly as important as what we communicate to our colleagues in scientific meetings. Our students, researchers and university administrators need to develop the kind of skills that will allow them to communicate about their work to a wider range of people. In this way more people can appreciate the work of scientists and scholars and more children will want to become them. An excellent initiative that I have heard about is the Wellcome Trust in the United Kingdom, which offers fellowships to students who agree that during their studies they will communicate about science to people of all ages from many walks of life.

The most painful part of what we have heard at this conference was what Debra Stewart and Diana Carlin conveyed to us about another important societal issue, namely that of international students in our universities. Once again there are questions that need to be asked. What did we think we were doing when we made it a virtue to attract international graduate students to our institutions? Were we only after their tuition fees? Were we after manpower for our laboratories? What is at risk if the fate of international students in American universities is endangered? I think that originally we may have begun encouraging international students to come to our universities as a sort of colonialism. Yet, in part, our aim was to educate them so that they might return to their home countries and build their own research and higher education networks. If that is true, then it should be a cause of joy rather than jealousy that graduate education in other countries is now a success. I think that Cambridge University, for example, should be proud of the fact that they accepted a young American man from a poor background and gave him a world class education so that he could return to the United States and become a leading figure in research and higher education in his own country. This young man was my father, and his graduate studies as an international student brought back enormous benefits to the people in the United States, not only to my own life but also to generations of university students in this country. Education is a kind of spark that we pass on to others. American universities have lit that spark for students from other countries in a remarkable way for the last 50 or more years. Will the present political situation extinguish it?

Why should we go on educating international students today? For one thing, they provide us with diversity, the kind that the Supreme Court decision about the University of Michigan is trying to defend, just at a time when we need it most. I have often wondered if we make the most of the diversity that international students bring to our campuses. Do we explore their lives and cultures and learn from them? Or, do we just try to convert them into fans for our sporting teams and expect them to learn about our way of life. One of our challenges is to figure out how we let the international students who are in our universities educate our North American students.

Let me give you an example from my university of another important aspect of educating international students. At McGill, we educate students from everywhere in the world. I consider this to be a great asset in a time when the people of the world lack understanding of each other. But I would like to explain two particular programs to you. For many years at McGill, we have had an Institute of Islamic Studies. About 10 years ago we received funding from the Canadian International Development Agency to bring Master’s and doctoral students to McGill to study Islamic thought. This is a partnered program with two religiously based universities that are primarily responsible for educating the teachers who will teach in the Madrasas of Indonesia. After receiving their graduate degrees from McGill, the students in the program are slated to return to Indonesia and become professors and administrators of the partner universities. Before I knew much about this program, I was sent to Ottawa to persuade the government agency to continue its funding. I had only a short time to read the background documents and decide what I should say about the importance of investing in Indonesian students at a time when Indonesia was no longer considered a developing country. While reading my documents, I was astounded to learn how many Muslim people live in Indonesia. This made me question why Muslim students from Islamic Institutions would come to McGill for a program in Islamic studies. However, the partnered funding proposal that I was reading made the case that at McGill's Institute the students could learn what was referred to as "rational" Islamic thought. The concept was that through educating the educators of the teachers of the Madrasas this form of religious thought would trickle down to millions of people in Indonesia. Reflecting on this, it became clear what case I should be making to the federal funding agency. I realized that the political consequences of these students' graduate studies had the potential to be extremely significant to the world. This episode occurred in the year 2000 when I did not have any idea of what world events would be scarcely one year later. On the train ride back to Montreal, I talked with one of the Indonesian university's officials. He had received his Ph.D. from the University of California-Los Angeles in Islamic Studies. He asked me what the funding agency was considering as they evaluated the proposal. So I asked him in return if he could explain to me what was different about the education he had received in Indonesia and the one he had received at UCLA. He told me that in Indonesia he was never asked what the Koran meant. Instead he memorized it or recited it but he was never taught to interpret it. From this conversation, I realized how dramatic a difference an education at our institutions could make. It can serve a crucial political and humanizing role. At McGill we also have a Middle East Peace Building Program. This brings students from Palestine, Jordan and Israel together on our campus to obtain a Master's of Social Work. The students do their professional practice placements in community centers in the border areas of their home countries. Their time at McGill provides them with a safe haven in which they can explore their commonalities and differences and get to know each other as human beings, not only as political foes.

Our universities need to think very seriously about the particular role that they can play in the interest of global well-being. Developing our research capacity in the sciences that are associated with security is important, but 9/11 was not due to a failure of science and technology. Rather, it was a failure to understand political, social and cultural forces. Higher education is an agent of change that develops human capacity, knowledge, and understanding. Above all, we must remember, as Debra Stewart pointed out, that education has always been a powerful weapon in times of uncertainty.

It has been a pleasure to have this opportunity to grow a little further in my own thoughts with you.

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2003

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