

# Research Innovation as a Pathway to the Future

*Merrill Series on  
The Research Mission of Public Universities*

A compilation of papers originally presented at a retreat  
sponsored by The Merrill Advanced Studies Center  
July 2015

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MASC Report No. 119  
The University of Kansas

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# Introduction

Mabel Rice

The Fred and Virginia Merrill Distinguished Professor of Advanced Studies and Director, Merrill Advanced Studies Center, the University of Kansas

The following papers each address an aspect of the subject of the nineteenth annual research policy retreat hosted by the Merrill Center: Research Innovations as a Pathway to the Future.

We are pleased to continue this program that brings together University administrators and researcher-scientists for informal discussions that lead to the identification of pressing issues, understanding of different perspectives, and the creation of plans of action to enhance research productivity within our institutions. This year, our retreat explored the subject of research innovation and the ways that innovation can forge a pathway to the future.

Our keynote speaker for the event was Dr. Ruth Watkins, Provost and Senior Vice President for Academic Affairs at the University of Utah. In her presentation she approached the topic of innovation within the context of scholarship and education, and how the three can be integrated in order to fulfill our promise in the 21st century.

Benefactors Virginia and Fred Merrill make possible this series of retreats: The Research Mission of Public Universities. On behalf of the many participants over more than a decade, I express deep gratitude to the Merrills for their enlightened support. On behalf of the Merrill Advanced Studies Center, I extend my appreciation for the contribution of effort and time of the participants and in particular to the authors of this collection of papers who found time in their busy schedules for the preparation of the materials that follow.

Eighteen senior administrators and faculty from five institutions in Kansas,

Iowa and Nebraska attended the 2015 retreat. Though not all discussants' remarks are individually documented, their participation was an essential ingredient in the general discussions that ensued and the preparation of the final papers. The list of all conference attendees is at the end of the publication.

The inaugural event in this series of conferences, 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 to ways to enhance individual and collective productivity. In 1999, we examined in more depth cross-university alliances. The focus of the 2000 retreat was on making research a part of the public agenda and championing the cause of research as a valuable state resource. In 2001, the topic was evaluating research productivity, with a focus on the very important National Research Council (NRC) study from 1995. In the wake of 9/11, the topic for 2002 was "Science at a

Time of National Emergency"; participants discussed scientists coming to the aid of the country, such as in joint research on preventing and mitigating bioterrorism, while also recognizing the difficulties our universities face because of increased security measures. In 2003 we focused on graduate education and two keynote 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. In 2004 we looked at the leadership challenge of a comprehensive public university to accommodate the fluid nature of scientific initiatives to the world of long-term planning for the teaching and service missions of the universities. In 2005 we discussed the interface of science and public policy with an eye toward how to move forward in a way that honors both public trust and scientific integrity. Our retreat in 2006 considered the privatization of public universities and the corresponding shift in research funding and infrastructure. The 2007 retreat focused on the changing climate of research funding, the development of University research resources, and how to calibrate those resources with likely sources of funding, while the 2008 retreat dealt with the many benefits and specific

issues of international research collaboration. The 2009 retreat highlighted regional research collaborations, with discussion of the many advantages and concerns associated with regional alliances. The 2010 retreat focused on the challenges regional Universities face in the effort to sustain and enhance their research missions, while the 2011 retreat outlined the role of Behavioral and Social sciences in national research initiatives. Our 2012 retreat discussed the present and future information infrastructure required for research success in universities, and the economic implications of that infrastructure, and the 2013 retreat discussed the increasing use of data analysis in University planning processes, and the impact it has on higher education and research. The 2014 retreat looked at the current funding environment and approaches which could be used to improve future funding prospects.

Once again, the texts of this year's Merrill white paper reveal various perspectives on only one of the many complex issues faced by research administrators and scientists every day. It is with pleasure that I encourage you to read the papers from the 2015 Merrill policy retreat on *Research Innovations as a Pathway to the Future*.

## Executive summary

### **Fulfilling our Promise in the 21<sup>st</sup> Century: Integrating Scholarship, Education and Innovation**

Ruth Watkins, Provost and Senior Vice President, University of Utah

- Public research universities are powerful institutions. We have a central role in the generation and dissemination of knowledge, and our work shapes and reflects the priorities of society. We strive to prepare lifelong learners capable of thriving in the multiple careers they will likely pursue. We have the unique role of preparing future scholars who will generate knowledge, meet the needs of industry and the academy, and serve as leaders.
- At the same time, we face challenges as we redefine our role. New competitors have emerged, technological advances disrupt traditional educational models, and demographic shifts in high school graduates require change in our approaches to recruitment and enrollment. The cost of higher education has outpaced inflation, and a sharpened emphasis on accountability has required us to more honestly examine both our successes and our limitations.
- Among the most urgent issues we face as public universities are the rate of baccalaureate degree completion and time to degree. One or two of every five students beginning college at the institutions in our region leaves without earning the baccalaureate. However, the difference in outcomes for those who do complete the baccalaureate, compared to peers with high school and those with some college, is striking. *Degrees matter.*
- Public research universities have a distinctive and exceptional opportunity to address the completion challenge. Four strategies for advancing undergraduate student success are: Creating proactive models of pathways to completion which match our present reality and meet student needs; connecting undergraduates with our scholarly efforts through involvement with research; employing data analytics to increase student success; and creating a makerspace to attract creative and talented students, and to actively engage these students through the completion of their degrees.

### **Reinforcing the Translational Bridge: Realizing the True Promise of Research Innovations**

Alexandra Thomas, Clinical Professor, University of Iowa

- Debate has been ongoing regarding how to realize the potential of translational work. While gains have certainly been made, hurdles persist which prevent us from fully achieving this promise. There are many areas that we might focus on to harness the potential of translational research. I suggest three areas that we could invest in to more completely produce healthcare gains for society: reward all members on the bridge from the laboratory to the clinic, support and sustain women in science, and engage society.
- *Reward All Members on the Translational Bridge from the Laboratory to the Clinic:* Fully including clinicians in investigations is critical on several important fronts. Fundamental research which is linked to applied research is more readily supported by the public. Further, clinicians bring back the pertinent, unanswered questions about the treatments to their laboratory colleagues, and this two-way dialogue is vital to making translational medical research

relevant. Ways to value all members of the translational bridge include encouraging diverse research portfolios, reconsidering what is valued in promotion and tenure and revisiting how awards and leadership roles are distributed.

- *Support and Sustain Women in Science:* Barriers to fully including women in the scientific enterprise still exist. Supporting and sustaining women in science is critical; equal pay and comparable recognition with awards still needs to be attained. We also need to make science and the environments in which it is practiced comfortable for women. Finally, we could better understand career breaks for having a family and proportionally give credit. In this we are asking science to support families which further ensures our sustainability and helps all stakeholders.
- *Engage Society:* The ability to tell our story has never been more relevant than today, when funding is short and we need to engage society to garner support for the vital work of discovery. Scientists need to articulate the value of their work - this means when the media calls, embrace the chance to discuss our projects. While this is not innately comfortable for many of us, perhaps we should strive to make it more a part of our culture, especially at public universities?
- The shared goals of better health outcomes and improved global quality of life, held by all stakeholders in the research enterprise can help move us collectively toward this vision. We might further consider that the public universities in the Midwest are uniquely situated to act on these opportunities based on our rich traditions of community and collaboration.

### **Building a translational research program in Neurotology at the University of Kansas Medical Center**

Hinrich Staecker, David and Marilyn Zamierowski Professor,  
University of Kansas Medical Center

Kevin Sykes, PhD, MPH, Clinical Research Director, Head and Neck Surgery,  
University of Kansas Medical Center

- The treatment of inner ear diseases such as hearing loss and balance disorders has been largely neglected by the pharmaceutical industry. Problems in drug development for the inner ear include difficulty of correct diagnosis, lack of real-time pathological evaluation and inability, to date, to turn years of basic science research into a clinical product.
- In the Division of Otology Neurotology at the University of Kansas Medical Center we have spent the last eight years developing a research program geared towards preclinical animal models of hearing and balance loss while in parallel developing a clinical trial infrastructure that can tackle hearing and balance clinical trials.
- This requires dedicated space and staffing, a good working relationship with the institutional research infrastructure and most of all, funding. Building this kind of program takes time but it becomes self-supporting through a range of funding mechanisms and has led to the development and implementation of the first human inner ear gene therapy trial at our institution.

### **Barriers to Clinical & Translational Research & Challenges of Investigator Initiated Multi-Center Clinical Trials**

Laura Herbelin, BSc, CCRP – Research Instructor, Department of Neurology,  
University of Kansas Medical Center

Richard J. Barohn, MD – Chair, Department of Neurology; Gertrude and Dewey  
Ziegler Professor of Neurology; University Distinguished Professor; Director,  
Frontiers: The Heartland Institute for Clinical and Translational Research, Vice  
Chancellor for Research; President, Research Institute: University of Kansas  
Medical Center

- Clinical Translation Research (CTR) requires an idea, interest/desire, talent, training, time, a team, regulatory support, space, money and study participants. A large team is needed to conduct a clinical trial, whether single site or multisite. Many clinical trials require multiple sites, especially in rare disease research (the focus of our research), in which recruitment is a challenge due to the rarity of patients.
- Sites should be chosen based on patient population, and willingness to recruit. As a member of a consortium, you may gain a foothold in conducting clinical trials. Handling of the regulatory issues is a challenge for every multi-site study. Each site may have to submit to their own IRBs for approval. However, there have been recent strides made in utilizing a single IRB on multicenter trials and there is a huge momentum at the NIH and PCORI levels to utilize a single IRB.
- There has been recently a push by the FDA for investigator-initiated studies to monitor their own studies. The budgets for investigator initiated studies rarely have the capacity to fund a robust monitoring program. Our approach represents a compromise; we do remote monitoring and have sites send a selected number of study records for review. If they are deficient, a higher level of monitoring can be activated. At KUMC, we have innovative solutions for recruitment, including the Frontiers registry, The Pioneers Community Research Recruitment Registry, and the Healthcare Enterprise Repository for Ontological Narration (HERON).
- Adding sites outside the US border adds a layer of complexity. European Union regulations try to unify regulatory process for studies across Europe. Using international sites is expensive for a budget on an investigator initiated trial and this needs to be factored into the budget. There are significant barriers in carrying out a multicenter trial as the coordinating site. These barriers can be overcome but it takes personnel, infrastructure, time, training and money. Leading a multicenter study takes knowledge and skill, but the rewards are great.

### **Nebraska Innovation Studio: A University-Based Makerspace**

Shane Farritor, David and Nancy Lederer Professor, Mechanical and Materials  
Engineering, University of Nebraska

- The University of Nebraska-Lincoln is creating a new makerspace called Nebraska Innovation Studio. Makerspaces are a growing trend across the world and some precedent for University makerspaces exists. A makerspace (sometimes referred to as a Fab Lab, Hobby Shop, or Hacker Space) is a community-oriented physical space where students and other members can build and create. The focus of a makerspace is on creativity, interdisciplinary collaboration, entrepreneurship, and education.



- Students from across campus and all community members will be allowed to join the Nebraska Innovation Studio and build their own original projects. Nebraska Innovation Studio is a both a physical space and a community. The physical space contains specialized tools & equipment (3D printers, laser cutters, computer controlled embroidery machines, machining centers, etc.) along with collaboration space that will allow students to create projects that they are passionate about.
- The community will provide specialized classes that will enable the students to physically realize their own innovations. These non-degree classes will expand and improve the student's education by allowing them to learn by doing. This experiential education will better show our students that the world is out there to be engaged and shaped.
- The Nebraska Innovation Studio will strongly contribute to the dynamic multi-disciplinary innovative culture that is a goal of UNL, and will allow for an innovative experiential student learning. It will foster entrepreneurship - there are multiple examples of new products created in makerspaces across the United States. In addition, it will be an attractive facility to encourage interactions between the University and the private sector. It will house expertise and equipment to quickly make prototypes to support the "fail fast & learn" model of innovation.

### **Creating and Sustaining Interdisciplinary Research Groups**

Mary Rezac, Tim Taylor Professor of Chemical Engineering,  
Kansas State University

- It is clear that from NSF funding trends, both the number and value of projects awarded to research teams have increased dramatically in the past decades. If academic research institutions are to compete successfully for these funds, they must support their faculty members and research staff in the development of functional and efficient research teams.
- *There are real and perceived barriers to multi-disciplinary research within academia.* In a 2004 study, the NAE concluded that there are multiple barriers to success of these research teams. It is interesting to note that the majority of the concerns relate to allocation of credit whether it be for considerations of promotion and tenure, publications, awards, or unit productivity. It would seem that active work to create a university culture that promotes and rewards members of interdisciplinary teams could go a long way to overcome these fears.
- The NAE study also surveyed principal investigators on what recommendations they would make to peers to facilitate interdisciplinary research projects. PIs believed that the single action to promote success was identification of a team leader. The leaders identified are individuals with sufficient subject area expertise to garner the respect of her or his peers while simultaneously having the managerial, organizational, motivational skills to put together and keep together a research team. Faculty members believe that leadership of interdisciplinary teams has negative consequences on short-term productivity. That leaves only full professors in a position to effectively lead large, multi-disciplinary research teams. Yet, 10 or more years into their careers, they may have received little or no training on how to succeed in this role.
- If we are to transition to this new era of interdisciplinary research team success, our organizations must develop mechanisms for identify, training, and truly rewarding team leaders.

A few mechanisms are provided for consideration: (1) provide an indirect cost return system that financially rewards the leader of a team project; (2) provide central support for personnel to support large, team projects with the completion of the reports and data collection frequent in these projects; (3) provide central support for evaluation of large, team projects; (4) develop and finance a university-wide research award that focuses on success as a team leader; (5) identify faculty members at all ranks with the skills and inclination to be successful team leaders, provide them with mentoring to improve their skills; (6) recognize the role of team leader in publicity and marketing materials.

### **Cuts and Guts: Public University Budget Hemorrhages**

Don Steeples, Interim Dean, College of Liberal Arts & Sciences,  
University of Kansas

- Since 1963, in Kansas, tuition has risen 5X faster than board and room. Tuition for an undergraduate in 1963 was \$107 for 17 hours of engineering courses at KSU. When adjusted for inflation, those 17 hours would cost \$832 in 2015 dollars. In contrast, the actual cost in fall 2015 at KSU will be \$4,660, an increase of more than five times the inflated cost.
- In Kansas, tuition has gone up 3X faster than the U.S. minimum wage. The minimum wage in the U.S. was \$1.25 per hour in 1963 and in 2015 has increased to \$7.25 per hour. In 1963, a student who worked for 651 hours at minimum wage could earn enough money for two semesters of tuition and of residence hall living at KSU. In 2015, a student would have to work **1,868 hours at minimum wage** to provide for two semesters of tuition and residence hall living.
- Since 2002, based on the Kansas experience, it seems reasonable to hypothesize that cuts in state-government funding for public universities across the U. S. have been mostly offset by tuition increases. Only two states (Alaska and North Dakota) increased funding per student between 2008 and 2013. In contrast, Arizona, Louisiana, and South Carolina decreased per-student funding by more than 40% between 2008 and 2013. During the same window of time, Kansas, Missouri, and Iowa all decreased per-student funding by between 20-30%; Nebraska decreased per-student funding by about 10%.
- Overall, state per-student funding is generally a picture of less per-student public financial support amid tuition increases. The tuition increases may or may not partially replace, totally replace, or exceed the cuts in public funding. However, decreased state support does not automatically mean tuition goes up. Louisiana and South Carolina cut per-student funding by more than 40%, but only increased tuition by about 14% and 21% respectively.

### **The American Research University and the Iowa Experience**

Daniel Reed, Vice President for Research and Economic Development,  
University of Iowa

- Universities are challenged to adapt and respond while preserving their core values in the face of exponential change. The irreducible core values that define academia are: original scholarship and research, student education and training, and societal engagement and services. Reflecting shifting societal expectations, the University of Iowa has launched initiatives to assist its faculty, staff and students in scholarship and research, technology transfer, economic development, and societal engagement. Here are a few examples:
- **Outreach.** The University of Iowa Mobile Museum is designed to allow annual replacement and refresh of its contents, and includes displays on university research and scholarship as

well as Iowa history, both natural and cultural. The museum travels across Iowa, visiting schools, libraries, community events, and the state fair. This statewide outreach exposes K-12 students and Iowans to research breakthroughs and the university experience.

- **Research Metrics.** Working with other members of the Committee on Institutional Cooperation (CIC), the University of Iowa is analyzing its research expenditures to identify their direct and indirect impact on the state economy. By showing where research funds are spent, as well as the number of faculty, staff, and students employed by research grants and contracts, the UMETRICS data provides clear and compelling evidence of the economic impact of research funding.
- **Ideation Summits and Salons.** To encourage transdisciplinary scholarship and collaboration, the University of Iowa regularly hosts research summits and salon events that draw from the entire faculty. By facilitating discussion among scholars and researchers across the arts, humanities, social sciences, engineering, medicine and business, our goal is to foster broad collaborations.
- **Internal Funding Initiatives.** The University of Iowa's internal funding program is structured to enable scholars and researchers to explore new directions, ones where they may not have the experience or data to be competitive for external funds. It also places high priority on rewarding high risk, multidisciplinary collaborations such as those that might emerge from ideation summits. In addition, these initiatives support acquisition of new instrumentation and facilities.
- **Faculty Media Training.** To aid faculty in communication, the University hosts seminars on the art of presentation, targeting both research and public audiences. We also host cohorts of faculty for intensive media training, working with professional journalists and journalism faculty. These daylong seminars include the capture and critique of brief video descriptions of research, discussion about how to interact with journalists, and techniques for effective communication with lay audiences. Faculty members leave the seminar with a video succinctly describing their research and its broader relevance.

### **Shifting the Paradigm of Large-Scale Achievement Assessment or, Help! I'm Lost; Does Anyone Have a Map?**

Neal Kingston, Professor, Department of Educational Psychology and  
Director, Achievement and Assessment Institute, University of Kansas

- The Dynamic Learning Maps Alternate Assessment was developed at the University of Kansas Achievement and Assessment Institute, and is designed for students with significant cognitive disabilities. We began this work with the goal of improving instruction and assessment for students with significant cognitive disabilities, but there is no reason this approach would not work equally well for all students.
- We had a team of researchers scour research literature for studies about how students learn academic content in English Language Arts and Mathematics. We identified a large number of learning targets, or *nodes*— knowledge, skills, and aspects of cognition - foundational to both disciplines. These comprise the Dynamic Learning Maps.
- We have broken down the maps to smaller mini-maps containing essential elements. Each of these mini-maps is relatively easy for a teacher to comprehend, and any individual

teacher only needs to be able to use at most one hundred of the mini-maps to guide instruction.

- Assessments are developed based on the learning map as opposed to being based on a list of content specifications. After the tests are developed and administered, we use statistical models consistent with our learning map for the assessment. We are interested in which particular nodes a student mastered – a concept that relates directly to the map. The use of learning maps makes it much easier for teachers to personalize instruction. In addition, reports based on learning maps could be dynamic and show us student progress over time.

## **The Trouble (and Opportunities) With Ed Schools in the Research University**

Christopher Morpew, Professor, College of Education, University of Iowa

- Ed School certification requirements present real constraints to the research capacity of Ed Schools. The pressure to meet state requirements in a timely manner gets in the way of opportunities that students in history and physics might have to engage in time-consuming research projects with faculty or pursue a second (or third) major.
- Ed Schools tend to hire experts in education rather than experts in specific disciplines. There are disadvantages, which include being overlooked by foundations and/or review panels at federal funding agencies that are quick to cede the high ground (and funding dollars) to economists or other scholars who have Ph.Ds. in academic disciplines.
- On the other hand, Ed Schools benefit from a multidisciplinary approach to research. Ed School professors, precisely because they are not trained in a single discipline, tend not to be trapped in the same methodologies and conceptual frameworks that might dominate a discipline. The recent growth in interest in schools and public education by large foundations like Gates is a second potential advantage for Ed Schools.
- Ed Schools are relatively inexpensive. Ed School researchers make less than their peers in the health sciences, business, and often less than faculty in natural and physical sciences. Start-up costs are less as well. Generally, expensive labs are not required. These cost advantages matter now and may matter more in the future.
- Ultimately, the trouble with Ed Schools is both real and a product of perception. The real part is a function of Ed Schools' longstanding links to historically marginalized populations and soft, applied problems. That is not likely to change. The perception part is something that Ed School and University leaders can do something about.

## **Social and Behavioral Sciences Research: Is now the time to invest?**

Steve Goddard, Associate Vice Chancellor for Research,  
University of Nebraska-Lincoln

- Funding for traditional disciplinary SBSR is becoming increasingly more competitive due to an increasing pool of applicants and decreases in SBSR federal funding. The result, as we see across the funding landscape, is lower federal funding rates. Research funding allocated to SBSR has remained a small proportion of the overall NSF research budget, declining from 4.9% in 1998 to 4.4% in 2014.
- The situation is dire for the smaller agencies that focus on SBSR. The Institute of Educational Sciences (IES), within the DoE, is likely to experience a significant cut (up to 27%). If the House has its way, ARHQ will be completely eliminated with its budget being zeroed out.

- Why do we conduct SBSR and what we hope to gain? Our long-term success in addressing major economic, health, energy, environmental and national security challenges depends on understanding the broader social, political and economic issues that serve as the context for addressing these matters. The answer to many of society's problems are known, the challenge is figuring out how to change behaviors to adopt solutions to the problems ailing our society.
- At UNL, we believe it is best to invest now, when the 'market is down', rather than wait until the 'market is hot'. We need to move from thinking of research defined by disciplinary boundaries and expertise to research foci that require the collaboration of researchers across disciplines, bringing diverse theoretical and methodological approaches to address a common research challenge.
- We believe SBSR will continue to play significant roles in addressing our societies biggest challenges. The growth opportunities, however, are in interdisciplinary and transdisciplinary team science approaches, rather than traditional single-investigator research projects. We are confident that our approach will position UNL as a leading institution in transdisciplinary social and behavioral science research.

## Fulfilling our Promise in the 21<sup>st</sup> Century: Integrating Scholarship, Education and Innovation

**Ruth Watkins**, Provost and Senior Vice President for Academic Affairs,  
the University of Utah

**P**ublic research universities are powerful institutions. We are vital in the development of human capital, attracting and engaging hundreds of thousands of students every year working toward baccalaureate, masters and doctoral degrees. We have a central role in the generation and dissemination of knowledge, at a massive scale and across a range of disciplines and emerging interdisciplinary fields. From the land-grant institutions brilliantly conceived in the Morrill Act, to the larger community of state flagship universities, our work shapes and reflects the priorities of society (The Lincoln Project: Excellence and Access in Higher Education (2015).

- Our collective research and creative activity solves urgent societal problems, promotes historical and cultural knowledge, fuels the innovations that create jobs, and infuses meaning and purpose in our lives.
  - We are instrumental in the development of talent, as we contribute to the workforce of creative thinkers and problem solvers who are capable writers, team members, innovators, citizens and leaders. Perhaps most central, we strive to prepare lifelong learners capable of thriving in the multiple careers they will likely pursue. As research universities, we have the unique role of preparing future scholars who will generate knowledge, meet the needs of industry and the academy, and serve as leaders. We continue to balance affordability, access and excellence in our institutions, even as state support has declined.
  - We stand on common ground with our communities – locally, regionally, nationally and internationally – working together on relevant issues, promoting vitality in our neighborhoods, and improving quality of life.
  - Our innovation extends technologies forged and founded through university scholarship into the public arena, generates jobs, and promotes healthy economies.
  - Our institutions are major employers, often among the largest in our communities.
- Clearly, public research universities have noteworthy records of impact and relevance. At the same time, we face striking challenges as we redefine our role in the 21<sup>st</sup> century. New competitors – nationally and internationally - have emerged, technological advances signal disruption in traditional educational models, and demographic shifts in the population of high school graduates ne-

cessitate change in our approaches to recruitment and enrollment. The cost of higher education has outpaced inflation as our institutions adapt to declining support from our state partners. A sharpened emphasis on accountability has required us to more honestly examine both our successes and our limitations.

Among the most urgent issues we face as public universities are the rate of baccalaureate degree completion and time to degree. Nationally, just over half of students entering four-year institutions earn their degrees within six years. Students from diverse backgrounds, including students who are the first in their family to attend college and students from low-income backgrounds, are even less likely to leave college with the degree they sought. For the institutions participating in the 2015 Merrill conference, six-year completion ranged from 64% to roughly 79%. One or two of every five students beginning college at our institutions leaves without earning the baccalaureate.

The completion of the baccalaureate degree has a transformative influence on well-being and quality of life. Degree completers have higher incomes and lower likelihood of unemployment and poverty, as well as a stronger sense of meaning and purpose in their work lives (Pew Education Research, 2014). During the most recent recession, four of every five jobs lost involved a person without a post-secondary credential. Perhaps most surprising is that individuals who have some college but no degree experience little benefit over their peers whose formal education concludes with high school; in contrast, the difference in outcomes for those who complete the baccalaureate,

compared to peers with high school and those with some college, is striking (Carnevale, Rose & Cheah, 2011; Pew Education Research, 2014). *Degrees matter.*

Economic vitality and innovation within a region are also heavily influenced by the presence of individuals with college degrees. By 2020, two-thirds of all jobs in the U.S. are forecast to require a post-secondary degree or credential (A Stronger Nation, 2015; America Needs Talent, 2015). Thus, it remains true that higher education – and significantly the attainment of the degree – is a powerful influence on both personal and societal advancement.

Despite these well-documented benefits, degree completion remains elusive for large segments of the U.S. population. Nationally, about 40% of adults ages 25-64 have attained a post-secondary credential (certificate, associates or baccalaureate degree), with only 34% completing the bachelor's degree (National Center for Education Statistics, 2015). The percentage of individuals from underrepresented backgrounds earning baccalaureate degrees in the U.S. is significantly lower; for example, only 15% of U.S. Hispanic adults has earned a bachelor's degree (NCES, 2015).

For decades, public research universities have focused on enabling access for talented students independent of their backgrounds, the visionary “right to rise” emphasis of the Morrill Act. In the 21<sup>st</sup> century, this noble vision is incomplete without parallel emphasis on completion. This expanded emphasis is imperative for the renewal, relevance and continued vitality of the public research university.

Public research universities have a distinctive and exceptional opportunity

to address the completion challenge. In addition to large scale and scope of influence, our missions of research and creative discovery, of innovation and engagement, afford us unique strategies and tactics to promote persistence and completion. How can public research universities, particularly those who add value through a less highly selective student population, improve attainment rates? How can we enlist the special attributes of our institutions to advance undergraduate student success?

#### **Four Strategies for Fulfilling Our Promise as Public Research Universities**

##### 1. Expand Pathways to Completion

We have long approached undergraduate education as if there was a single path to success: recruit talented high school students who are emotionally and intellectually connected to our residential institutions and engage these students for four-year plans of study through completion. This traditional model applies to a segment of our students, but has not held true for many undergraduates and seems even less applicable given the advent of new competitors, online educational options, and the lower-cost attraction of two-year community colleges for many students who ultimately aim to attain the baccalaureate. Creative, proactive models of *pathways to completion* are needed to better match our present reality and effectively meet student needs.

A variety of pathway models are in development across the nation. At the University of Utah, we are working with our partner institution, Salt Lake Community College, to direct prospective U students who would be well-served by starting at SLCC to a shared program,

ACCESS U, that engages them in both institutions with planning for completion from the beginning of their college careers. ACCESS U students have academic advisors and student success advocates in both institutions, and take at one course per semester from the U during the time that they are enrolled at SLCC. The concept is a welcoming, seamless approach to college through two different institutions, with a completion plan from the outset. The goal of the program is to prevent the loss of many talented students who begin at a community college with the aim of the baccalaureate, but who ultimately do not successfully make the transition.

Pathway programs with varied features exist at several institutions, including the University of Illinois and Clemson University. Key features of impactful programs are the coordination and communication of efforts across community colleges and four-year institutions, the simultaneous rather than sequential approach of traditional transfer, and the focus on a shared *Plan-To-Finish* from the outset.

##### 2. Exploit the Linkage of Research and Education

Perhaps the most obvious opportunity we have as research universities is to integrally connect undergraduates with our scholarly efforts. We believe that scholarship informs teaching, and in turn, that educational efforts enlighten and enliven scholarship. Furthermore, we espouse that learning from scholars who are active in the generation of knowledge – and the opportunity to take part in the generation of knowledge – is what makes for vibrant undergraduate education. We certainly articulate this in



student recruitment efforts as the fundamental rationale for choosing a public research institution over other higher education options. In reality, though, relatively few undergraduates are engaged in the generation of knowledge, and an even smaller number are closely connected with faculty scholarship. It seems likely that first-generation students, especially students who are working many hours per week to finance their education, are even less likely to benefit from the deep learning experience that can come from involvement with research. We also know that students who feel that they belong in a university are more likely to persist (Strayhorn, 2012); it's difficult to imagine a better way to "belong" at a research university than to be part of research. How can we enable more students to connect with their education through research? Can we make this a part of the larger completion agenda?

Many of us became interested in scholarship through research with a faculty member who demonstrated an interest in our success and/or our potential. The traditional approach of volunteering in a faculty research activity continues to be valuable, but it cannot be the only way that research universities create opportunities for students to connect with the institution or to link education and scholarship. Three extensions of the traditional model may enable broader participation in research.

- For undergraduates who are working to pay for education, creating a work-study type model specifically dedicated to compensate students for time spent with faculty on scholarship can open the door of opportunity and

learning through research, opportunities otherwise inaccessible.

- As we have expanded access to learning abroad through new mechanisms, such as one- to two-week international experiences linked to courses, we might similarly devise ways to enable every undergraduate to connect directly to the research enterprise at some level, rather than maintaining a one-size-fits all ideal.
- Virtually all of our institutions are engaged in cluster hiring of faculty to strengthen our ability to solve urgent societal problems, areas that cross departmental and college boundaries, such as climate and water, behavioral health, and sustaining biodiversity. These areas are ideal for undergraduate participation given the visibility and impact of the scholarship. As funding is provided to support clusters, small amounts of supplemental funding could be made available to allow undergraduates to participate in these research efforts. Seed funding could enable success with larger external support in these strategic areas.

### 3. Employ Data Analytics to Increase Student Success

Large public universities have a wealth of data, largely unexamined, that can inform our efforts to increase persistence and completion. We have hundreds of thousands of cases from which description and prediction of student success can be analyzed, from student characteristics at the beginning of college to course and program enrollment and sequencing, from student engagement on campus to student use of a learning management system. Detailed data analytics

are perhaps the most promising element of the portfolio available to large research universities for increasing completion.

Many institutions are beginning to realize the potential of data analytics to drive change and improve outcomes for students. A few insights from this work are offered here. At the University of Utah, we have discovered that students who complete within six years perform differently in their academic work beginning in the first semester, relative to those who do not complete within six years. In concert with demographic characteristics and other relevant variables – such as living in the campus housing and enrolling full-time, both positively associated with completion - we are using first semester performance to create a “success index” and assertively engaging students from the beginning of college with a Student Success Advocate (a new position created to promote completion and engagement with the institution). Without the Student Success Advocates, we did not have the personnel in place to optimize data analytics. We’ve learned that some combinations of courses in the first year are more and less likely to be associated with completion (e.g., advanced writing and chemistry are a “poison pair” for freshmen, associated with lower overall academic performance). And we’ve learned that we can better serve some students through a pathways program in partnership with a community college, as outlined above.

As we improve our analytic capabilities, we gain in our effectiveness in providing timely guidance to students. In parallel, we are learning about what matters most in persistence, whether financial assistance, academic guidance, or

creating a sense of community and belonging for students, and aligning our actions, interventions and resources accordingly. The potential to improve outcomes through analytics and innovative tools that move from data to information is significant.

#### 4. Extend Innovation and Entrepreneurship to Undergraduates

Many public research universities identify technology transfer, entrepreneurship and economic development as a fourth element of their missions, in concert with scholarship, education and engagement. Yet the integration of this component of our work with the student experience, as a tool to promote student engagement through completion, has been relatively unexplored. We attract and serve many students with entrepreneurial interests and creativity. These students may major in any field but share an interest in using their university experience, while working toward their degrees, to make something new, create a technology, solve a problem, improve a service or launch a company. Can we extend the university mission of innovation and entrepreneurship to undergraduates, as a strategy to both attract creative and talented students, and to actively engage these students through the completion of their degrees?

We are exploring this possibility at the University of Utah, with the support of a lead donor and other investors, through the creation of a unique residence-maker-entrepreneur space. The Lassonde Studios will incorporate space for 400 student residences, in a variety of types from small individual “pods” to more traditional residence space, to large lofts for groups of students. The Studio

also houses a 20,000-square-foot “garage” for students from any major on campus to make prototypes, launch companies, or learn through presentations. The facility, particularly the garage, will be the hub for innovators, makers and entrepreneurs. The garage is located on the ground floor of the building, and will incorporate the tools necessary for student entrepreneurs to collaborate and begin their projects, including 3-D printers, co-work space, prototyping tools and more. The Lassonde Studios are part of a larger vision, the Lassonde Institute. The institute provides opportunities for undergraduates, graduate students, and faculty to learn about entrepreneurship, venture development and launching companies. See <http://lassonde.utah.edu/directory> for additional information.

As this vision progresses to reality, we plan to monitor the college trajectories of undergraduates who live in the Lassonde Studios, participate there in learning opportunities, and utilize the maker and entrepreneurial spaces in the garage. It is our hope that the type of engaged learning that will take place in this space will be associated with increased persistence and completion.

### Summary

As public research universities, we continually seek balance between our responsibilities as the institutions charged with the generation and dissemination of knowledge and our duties in engaging

and educating individuals prepared for lives of impact as leaders and citizens. In the latter endeavor, we have the opportunity and the duty to leverage our strengths as research universities to extend our focus from access to our institutions to completion of the baccalaureate degree for every talented undergraduate student we recruit.

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# Reinforcing the Translational Bridge: Realizing the True Promise of Research Innovations

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In 2005 Elias A. Zerhouni, then director of the National Institutes of Health published a seminal essay, “Translational and Clinical Science – Time for a New Vision” in the *New England Journal of Medicine*.<sup>1</sup> This work challenged stakeholders in the scientific enterprise to consider new models to “translate the remarkable scientific innovations we are witnessing into health gains for the nation.” Since then debate has continued regarding how best to realize the potential of true translational work. While gains have certainly been made, historic, structural and philosophic hurdles persist which prevent us from fully achieving this promise.

## *Clinical Faculty Perspective*

With this background, I offer one perspective, that of a clinical faculty member at a large public institution who has also recently served as a leader of the elected faculty body at the University of Iowa, on areas we might target as we try to take bench-top discoveries to the bedside or the clinic. A significant portion of my professional time is spent on direct patient care. This indeed is what drives my goal of participating in the conversation of how we can provide ever-better care for patients with breast cancer and ultimately for all patients.

My personal research spans several areas. At my institution I lead federally funded clinical trials in my discipline of breast oncology. I also direct industry funded clinical trials and partner with laboratory investigators to bring investigator-initiated studies to the clinic. One study which is currently open for enrollment looks at the role of inhibiting the RET receptor in hormone receptor positive breast cancer. Other translational

work includes work investigating novel agents to treat chemotherapy-induced neuropathy and studies looking at new circulating serum markers of breast cancer.

Research I direct involves a collaboration of faculty from the Colleges of Medicine, Pharmacology and Public Health with the objective of utilizing the SEER (Surveillance, Epidemiology, and End Results program of the National Cancer Institute) data and other data sources to address questions related to breast cancer treatment and outcomes. My personal work seeks to answer questions which directly pertain to our patients, and looks at issues that we find frustrating in the clinic. Finally, I initiated and serve as the principal investigator for the University of Iowa Breast Molecular Epidemiologic Resource, which is a prospective study of tissue and epidemiologic data for individuals who are at high risk for or are diagnosed with a proliferative disorder of breast tissue. As of March 2015 over 1,000 patients have enrolled in

this registry. This has served as a resource for bench investigators looking at a variety of questions in breast cancer. Notable recent externally funded work includes examining obesity, inflammation and breast cancer and a study looking at the role of novel fusion transcripts in breast cancer.

There are many areas that we might, as a community, elect to focus on to truly harness the potential of translational research. With the lens that I bring to clinical research and the healthcare enterprise, I put forth three areas that we could invest in to more completely produce healthcare gains for society: reward all members on the bridge from the laboratory to the clinic, support and sustain women in science, engage society. We might further consider that we, at public universities in the Midwest, in certain ways are uniquely situated to act on these opportunities based on our rich traditions of community and collaboration.

**Reward All Members on the Translational Bridge from the Laboratory to the Clinic:** Since the 2005 statement by the National Institutes of Health Director, scientific leaders have worked to embrace this model. An entire body of literature has evolved on “team science” which focuses on collaboration from bench to bedside or clinic as well as in cross-disciplinary work and cross-institutional work. Some have shown that while such coordination can have a lead-time, it ultimately demonstrates higher productivity with regard to publications and inclusion of many co-authors.<sup>2</sup> However meaningful opportunities for respect of all contributions still exist. Traditional hierarchies in education persist.

Some argue that clinical research or including clinicians in research dilutes the rigor of academic work.

However, fully including clinicians in investigations is critical on several increasingly important fronts. Fundamental research which is linked to applied research is more readily supported by the public. Importantly, engaging those delivering the products of bench top investigations to patients further provides the opportunity for clinicians to bring back to their laboratory colleagues the pertinent, unanswered questions. This two-way dialogue is vital to making contemporary medical research relevant. Opportunities to fortify this communication and value all members of the translational bridge include encouraging diverse research portfolios, reconsidering what is valued in promotion and tenure and revisiting how awards and leadership roles are distributed.

**Support and Sustain Women in Science:** Some might argue that women have made great advances in participating in the scientific enterprise. However, the barriers to fully including women remain. We really need to look no further than the very recent comments by Nobel Laureate Tim Hunt who stated, “...let me tell you about my trouble with girls...three things happen when they are in the lab. You fall in love with them, they fall in love with you, and when you criticize them, they cry.”<sup>3</sup> In 2013 Nature dedicated an entire issue to the topic of women in science. This publication was dedicated to a long-time editor Maxine Clarke who for years was known for her high scientific standards and for asking, “Where are the women?”

Supporting and sustaining women in science is critical, as ultimately unless women are equal partners, society will be deprived of this intellectual resource. A myriad of opportunities exist to fully include women in our work. Important advances would include rewarding women equally. Equal pay and comparable recognition with awards still needs to be attained. We also need to make science and the environments in which it is practiced comfortable for women. Do we need to feminize science? No. Perhaps more aptly we could allow practicing science to be feminine. I would argue that in breast oncology, I have found a discipline which can have a very feminine aspect to it – can we expand that to allow it as part of other fields, would that help lung cancer and colon cancer patients? What about research in technology fields? Finally, we could better understand career breaks for having a family (which also ultimately helps men on a variety of levels) and proportionally give credit as one young scientist recently describes.<sup>4</sup> In this we are asking science to support families, which further ensures our sustainability and helps all stakeholders.

**Engage Society:** The eloquent Harvard scientist Stephen Jay Gould who could magnetically draw the public to science explained his skill once stating, “So many scientists think that once they figure it out, that’s all they have to do, and writing it up is just a chore. I never saw it that way. Part of the art of any kind of total scholarship is to say it well.”<sup>5</sup> Perhaps at no time has this ability to tell our story been more relevant than today, when funding is short and we need to en-

gage society to garner support for the vital work of discovery. I am able to deliver novel life-saving therapies to women today that were not available just a few years ago. Perhaps our community should more regularly showcase these incredible successes in ways that speak to non-scientists? What about the other side of this story, when we use the societal resources we are given poorly. Some in academia have criticized the Golden Fleece award, arguing that to succeed we need to have failures. Perhaps this is true to some extent, however the days of funding, philanthropic or governmental, for clearly irrelevant research are over. To maintain credibility with society we must be excellent stewards of public and private resources. We must show society, in language they understand, that what they award us helps overcome disease, hunger, poverty and leads to a better quality of life.

In engaging society with our work, we have another opportunity to collaborate across the translational bridge. Scientists need to articulate the value of their work – but can also collaborate here with their clinical colleagues– who sit at the nexus with the public and directly understand the value of scientific advances. We should use resources wisely and with respect and take opportunities to showcase meaningful, transformative research innovations. This means when the media calls, embrace the chance to discuss our projects. While this is not innately comfortable for many of us, perhaps we should strive to make it more a part of our culture, especially at public universities.

## Conclusion

The prospect of better realizing research innovations at the forefront of science holds immense promise for improved health and social outcomes. As Dr. Zerhouni wrote, "We now aim to stimulate the development of a brighter vision for translational and clinical research, to ensure that these disciplines remain powerful engines of creativity." I have tried to outline several achievable, and also imperative opportunities to come closer to fully attaining this goal. Undoubtedly some barriers will need to be removed, as again Dr. Zerhouni outlined: "...the NIH has the responsibility to work toward dissolving the artificial barriers that inevitably spring up...We persevere in our determination to provide opportunities for the research community and to challenge the status quo in transformative ways." Certainly, the shared

goals of better health outcomes and improved global quality of life held by all stakeholders in the research enterprise can help move us collectively toward this vision.

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## **Building a translational research program in Neurotology at University of Kansas Medical Center**

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**T**ranslational research has been a common catchword in the NIH's effort to turn basic research into solutions for clinical problems. Despite a range of very successful programs in a range of medical specialties, the effort has not been largely successful for translational research of inner ear issues. Clinical otology currently suffers from a complete lack of medications to treat what really are amongst the most common neurodegenerative problems in man. Sensorineural hearing loss is almost ubiquitous by age 70 and vertigo represents one of the most common causes of primary care visits in the United States.

Compared to a similar organ system, the eye, there has been little true translational research despite years of basic science research and little understanding within our clinical subspecialty of how to actually make this happen. To most, translational research means disease research within an animal model. In this paper we will review our pathway to build a hearing and balance research infrastructure within the department of Otolaryngology Head and Neck Surgery at the University of Kansas Medical Center, and how we used that infrastructure to translate ongoing gene therapy research into human clinical trials.

The World Health Organization recently recognized the burden of hearing loss and estimates that 5% of the world's population is disabled by this condition (<http://www.who.int/mediacentre/factsheets/fs300/en/>). Currently we are limited to amplification (or in case of severe

hearing loss, cochlear implantation) as a means to restore hearing. Both of these are helpful but not ideal solutions to this very common problem. Development of medications for inner ear disease has been slow due to inability to biopsy the inner ear for analysis and the lack of correlation between clinical hearing and vestibular testing and site of lesion within the inner ear. Additionally it is only very recently that genetic testing has been available that can identify congenital or adult onset progressive hearing losses (Shearer, DeLuca et al. 2010).

Compared to other organ systems pathologic evaluation of human ear tissue is complex. What we know is derived from human temporal bones that have undergone decalcification and histologic evaluation often years after the active disease process is passed. The biology of the inner ear is complex and drugs that affect inner ear function often will also affect the



central nervous system, making systemically delivered medications difficult to apply. Basic science research has focused, broadly speaking, on several different research strategies with translational potential. These include delivery of growth factors to maintain our ganglion integrity, use of antioxidants as process factors to protect the interview trauma and hair cell regeneration.

Our lab has largely focused on the development of gene therapy technology for inner ear applications to help implement some discovery research going on in numerous other research groups. One of the relative advantages of the inner ear is that it can be locally accessed. Drugs can be delivered through the middle ear with diffusion of substances through the round window or through the stapedio-vestibular ligament or when larger molecules are involved, through direct injection into the inner ear. When we were initially looking for a translational research project to undertake, hair regeneration was an easy target since we have a quantifiable outcomes measure, namely the number of regenerated hair cells produced which could then be correlated to hearing or balance function. The molecular basis of hair cell regeneration has been established for a number of years. The transcription factor *atoh1* is responsible for genesis of hair cells during development in vertebrates. Multiple researchers have demonstrated that the overexpression of *atoh1* results in genesis of hair cells that are innervated and show recovery of function in mammalian models of ototoxicity (Baker, Brough et al. 2009). Delivery of *atoh1* therefore could

be a target for a translational research program.

When the project was undergoing its initial development phase we decided to target balance disorders caused by aminoglycoside ototoxicity. Patients who received gentamicin or other aminoglycosides for severe infections often end up with bilateral vestibular hypofunction despite adequate monitoring of blood aminoglycoside levels. Since we know the mechanism by which aminoglycosides damaged hair cells, a patient with loss of vestibular function with a history of aminoglycoside usage can be identified as a target for hair cell regeneration. An additional advantage of targeting the vestibular system is that there is no cochlear implant equivalent yet.

Despite early successes in regenerating hair cells in animal models of both hearing loss and vestibular dysfunction, numerous hurdles remained in the development process. Moving a drug candidate forward required calculation of dose response curves and understanding of the dosing relationships within the limited space of the inner ear. Additionally, analysis of potential downstream complications and longevity of regenerated hair cells had to be conducted. Animal hair cell loss models and drug delivery models had to be modified so that they could be used in contract research organizations where repeated experiments using GMP developed vector and GLP practices could be carried out. The record-keeping and expense associated with this is generally outside of the ability of the basic research lab. Funding of these type of experiments is difficult, since it is not really discovery research and many

study sections think that this type of research should be done by pharmaceutical companies. However, pharmaceutical companies will not pick up a potential product until this type of data is available to them at least in an early form.

In parallel to drug development efforts we had to establish a program for conducting clinical trials for inner ear disorders. Most clinical trial organizations or sections within the university hospital where clinical trials are conducted lack the ability to evaluate hearing and balance disorders. This is mainly due to the complex equipment and infrastructure needed to perform these types of evaluations. As always, putting new infrastructure in place requires funding. We set out to establish a hearing clinical trials program in 2007. Our initial efforts targeted device trials such as cochlear implants and implantable hearing aids. This provided the funding to cover the cost of an audiologist to perform testing and screen pa-

tients. The establishment of the hearing clinical trial program was overseen by Kevin Sykes (co-author). He had an appointment to the institutional review board (IRB) and initially oversaw integrity data collection and managed contacts. Our experience with running device trials and having infrastructure in place for hearing testing and a full-time liaison to the research office allowed us to attract early-stage drug clinical trials for tinnitus and Ménière’s disease. We then added a research fellow, generally a student who had completed college and wanted to spend a year in clinical research, to help manage the growing number of patients. In 2012 we hired a full-time research nurse which was needed to launch the gene therapy clinical trial. The growth in income from otology clinical trials during this time is shown in **Figure 1**.

In addition to covering the otology trials, putting clinical trial infrastructure into place has also opened opportunities

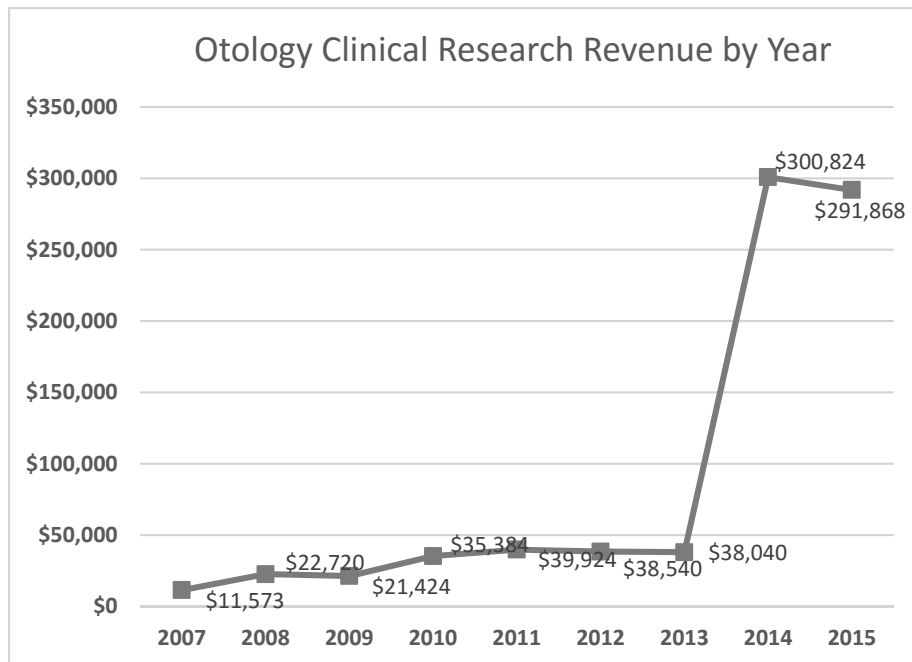


Figure 1: Income derived from the KU Otology clinical trial program over time.

for other subspecialties within otolaryngology to provide clinical trials and bring in income to grow the academic mission. Establishing an infrastructure for complex trials such as inner ear gene therapy is vital, since these are high-risk trials that require time-consuming applications to the institutional IRB and prolonged contract negotiations with the trial sponsor. Additional staffing is also required to manage the flow of patients. Our current gene therapy trial requires two pretreatment visits and monthly visits for six months after delivery of the drug. Each of these visits takes two days, therefore scheduling and ensuring that audiological resources are available, especially when patients start to overlap, is important. All of this cannot be done by a lone clinician.

Having put a hearing research program together, we are now able to attract the interest of both preclinical and clinical stage research programs. The basic science lab has a subcontract with an early stage pharmaceutical company that is looking at our expertise in animal modeling to test a new nano particle for drug delivery to the middle ear space. The clinical research unit is now involved with two new phase 3 trials for tinnitus and for Ménière's disease. It is only due to our publication record and our track record of working with several contract research organization and being able to provide clinical material for a number of trials that we are able to do this. Academic institutions generally cannot compete with

private institutions that make money from clinical trials.

Most of the private providers of these services focus on straightforward internal medicine type clinical trials and are competitive because of lower overhead costs and more straightforward contract negotiations with the sponsor. Many of these institutions also use private IRBs which are often more straightforward to navigate than a University IRB. The advantage of being an academic center is that we have a large base of patients with a number of rare diseases, and have infrastructure to support the testing and treatment of these diseases. This is true not only of neurotology but other subspecialties as well. Establishment of a successful translational research program requires a track record and most of all, an experienced and dedicated support structure.

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# Barriers to Clinical and Translational Research and Challenges of Investigator Initiated Multi-Center Clinical Trials

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**W**e have identified 10 barriers to overcome to conduct clinical translational research: 1) an idea, 2) interest/desire, 3) talent, 4) training, 5) time, 6) a team, 7) regulatory support, 8) space, 9) money and 10) subjects or study participants. We discuss the essential elements in overcoming these barriers, including programs initiated at KUMC for training and conducting clinical translational research. We also discuss challenges related to organizing and running a multicenter investigator initiated trial.

## **Spectrum of Translational Research**

Translational research has now been divided into at least four categories. T1 research (Translation to Humans), involves pre-clinical animal studies, first in human safety, tolerability and pharmacokinetics studies. These first in human trials are conducted first in a normal population but often that is carried over into a population that the compound is targeting. The focus of this phase is discovery and safety. This corresponds to FDA Phase I trials.

The T2 research (Translation to Patients) involves clinical trials that examine the effects of medication on a defined population. T2 research encompasses FDA categories of both Phase 2 and Phase 3 trials. FDA defines Phase 2 trial as a trial in which preliminary efficacy data with additional safety data is obtained. This

usually this study involves less than 100 patients and depending on the population can be a single site or a multicenter trial. FDA Phase 3 trials are classified as a **pivotal efficacy trial**. These trials are large and often multicenter. The focus in T2 research is both on safety and efficacy.

T3 step is the Translation to Practice. The focus of T3 research is ‘getting the word out’ and putting that medication, procedure or behavioral intervention into practice, or implementation, dissemination and communication. In FDA terms, this is called post marketing Phase 4 research.

The next step is T4, Translation to Populations phase. These are usually community studies, policy studies and population outcome studies. The focus of this final phase is to improve population health. There is no FDA Phase equivalent

to T4 research. Finally, T5 research has sometimes been used to describe international medical research.

Translational science refers to the study of methods in order to do translational research. This is a new concept that the NIH is now emphasizing. For example, comparing different types of recruitment tools to see which is most effective would be considered translational science.

6) a team, 7) regulatory support, 8) space, 9) money and 10) subjects or study participants.

Tools to overcome these barriers are available through multiple resources at medical centers, but the NIH/NCATS Clinical and Translational Science Award (CTSA) program is foremost in supplying these infrastructures to do CTR. At KU and in our Kansas City region our CTSA program is called Frontiers, the Heart-

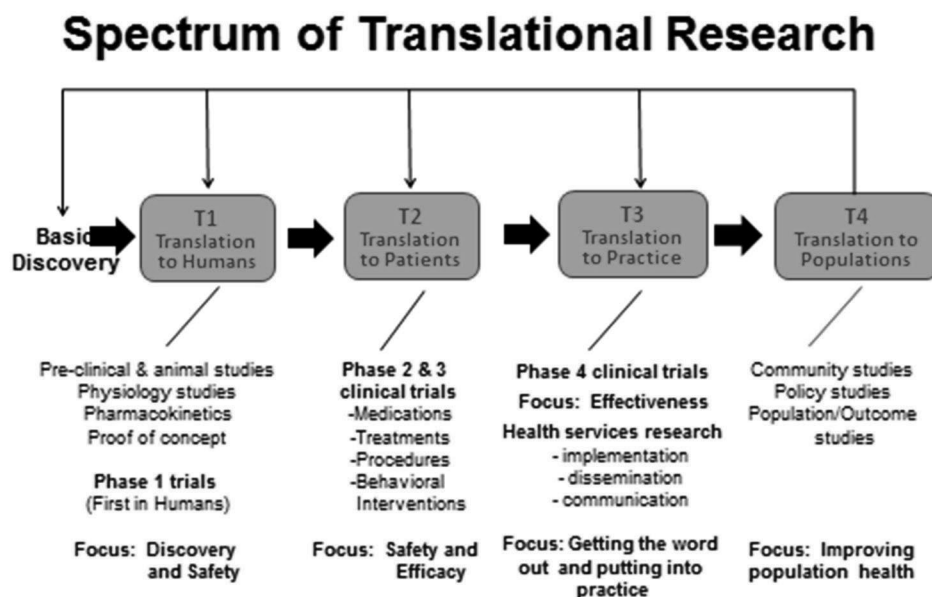


Figure 1: Spectrum of Translational Research

### Barriers (and Essentials) to Clinical and Translation Research

What barriers do investigators face in attempting to conduct clinical/translational research? We have identified 10 barriers that investigators must overcome for a successful study. In essence there are also essential strategies because if you do not have them, you cannot overcome the barriers to initiate and conduct Clinical Translation Research (CTR). To do CTR, you must have 1) an idea, 2) interest/desire, 3) talent, 4) training, 5) time,

land Institute for Clinical and Translational Research.

We successfully overcame these barriers in conducting several multi-center trials. We have recently coordinated and completed the following FDA Phase 2 (T2) studies:

- *Therapeutic Trial of Mexiletine in Non-Dystrophic Myotonia* FDA-IND # 77,021(FDAOOPD – RO1-FD003454)<sup>1</sup>
- *Safety and Tolerability Trial of Arimoclomol for Sporadic Inclusion Body Myositis* FDA-IND # 76,773<sup>2</sup>

- *Phase II Trial of Methotrexate in Myasthenia Gravis* FDAIND #101,306 (FDAOOPD – RO1-FD003538)<sup>3</sup>
- *A Multi-Center Screening Trial of Safety and Efficacy of Rasagiline in Subjects with Amyotrophic Lateral Sclerosis (ALS)* FDA-IND 104,360<sup>4</sup>

Only the mexiletine was a positive trial showing a definite benefit of the drug, for muscle stiffness in patients with rare genetic sodium or chloride mutation. Even in trials which do not have a “positive” result in favor of the drug, we learn a great deal of information regarding the CTR process by performing such studies. It is essential to publish results of negative or indeterminate trials so that health caregivers and patients can be informed. By law, it is now required to enter all data on a trial when it is complete and in clinicaltrials.gov. It is required to register all trials in clinicaltrials.gov at the start of a study and then to put the final data online.

We are currently coordinating the following multicenter trials:

- *Phase 2 Study of Rasagiline for Treatment of Amyotrophic Lateral Sclerosis* FDA IND# 104,360 (FDAOOPD-R01-FD003739)<sup>5</sup>
- *Patient Assisted Intervention for Neuropathy: Comparison of Treatment in Real Life Situations (PAIN-CONTRoLS)* (CER-1306-02496) – a FDA Phase 4/T3 comparative effectiveness study.<sup>6</sup>
- *Open Label study of subcutaneous immunoglobulin (SCIg) in myasthenia gravis* FDA-IND #: 15927 (Investigator Initiated - Pharmaceutical funded)<sup>7</sup>
- *Pilot Study of Acthar® Gel in Chronic Inflammatory Demyelinating Neuropathy* FDA-IND #126318 (Investigator Initiated - Pharmaceutical funded) – no clinicaltrials.gov assigned yet

*thy* FDA-IND #126318 (Investigator Initiated - Pharmaceutical funded) – no clinicaltrials.gov assigned yet

- *Phase II Study of Arimocloamol in IBM* FDA-IND # 76,773 (FDAOOPD-RO1FD004809) – no clinicaltrials.gov assigned yet

The funding agencies for these trials have been the FDA Orphan Products Division (which funds rare disease research), the new Patient Center for Outcomes Research Institute (PCORI); and industry, through their investigator initiated grant programs. Let’s examine the barriers mentioned above and how we overcame them.

#### **Barriers/Essentials to doing Multi-Center Trials: Interest/Talent/Time/Training**

Dr. Francis Collins, Director of the National Institutes of Health spoke at the Association for Clinical and Translational Science (ACTS) meeting in 2015. He reported that there was a crisis in the number of physicians doing research. How do you convince young faculty to include research in their career path and how do you train young physicians to conduct research?

The traditional MD/PhD pathway usually does not lead medical students to CTR and clinical trials. Rather these students generally focus on early T1 laboratory research. We believe that MD/PhD programs should be modified so that the PhD can be obtained in CTR. This is currently being done at a few medical schools but it may be the best pathway to get a study early in their career to pursue CTR post residency.

Currently in Frontiers, our NIH CTSA program, we do have a training

program (TL1) where a medical student takes a year between their first and second year to do a CTR research project with a mentor and obtain a Master of Science in Clinical Research. Our TL1 program is open to Medical, Dental and Pharm D students but we have limited funds and train only four per year. To date we have had 16 students go through Frontiers TL1 program. Therefore, the number of students that can participate each year are few, but it does allow a selective number of students their first foray into CTR. The MS-CR program is 33 credit hours with the student thesis as the project.

Unfortunately, historically much of the training for CTR has been on the job and occurs during fellowship or junior faculty years for MDs/DOs. Through Frontiers, we have designed a core of 16 introductory lectures (Introduction to Clinical Research) that we encourage medical students, residents, fellows and PhD doctoral students to take. This is offered every Thursday night in a 1.5 hr seminar each fall. For those interested in further education in CTR, they can take the courses that the TL-1 students take over a longer time, 1 or 2 courses a semester. They can therefore obtain their MS-CR over 2 to 5 years. This is often done by junior faculty.

There are some new CTR training activities at NIH/NCATS. One has come through a CTSA grant, Enhancing Clinical Research Professionals' Training and Qualifications (ECRPTQ), in which Tom Shanley, MD and Richard Barohn, MD are PIs. As a result of the ECRPTQ effort, it is now recommended that all investigators and coordinators involved in clinical

trials complete and pass online Good Clinical Practice (GCP) training. This will become the new floor for training investigators and coordinators conducting trials. In the second phase of this initiative competency requirements for conducting clinical trials are being developed and additional training towards these competencies will be proposed. This process is expanding on an earlier joint task force on clinical trial competencies.<sup>8</sup> In addition, the NCATS/CTSA Workforce Development Task Force (Richard Barohn co-chair), is starting to develop these new courses for clinical trials research, and other training modules including one for community-engaged research.

As mentioned above, the majority of training that young investigators obtain is through on-the-job training. Usually the young faculty or student will have a senior clinical investigator to serve as a mentor and the training is accomplished through this mentorship. The following is an example from research project, Therapeutic Trial of Mexiletine in Non-Dystrophic Myotonia. Jeff Statland MD became involved with Dr. Barohn on this project immediately following medical school and throughout his neurology residency. This is unusual for a resident to be so actively involved in a multicenter clinical trial. Dr. Statland ended up becoming the first author of the paper published in JAMA.<sup>9</sup> He then did a NIH funded Clinical Neurotherapeutics T32 Fellowship at the University of Rochester and he is now on faculty in the Department of Neurology at KUMC where he is designing and implementing neuromuscular trials. He is a KL2 scholar on the

Frontiers CTSA NIH grant and he is mentoring studies, fellows, residents and junior faculty on CTR.

Additional barriers facing young investigators is finding time from clinical and teaching duties to participate in clinical research. There is a salary discrepancy between clinical income and income from research work. This is not a new problem. Dr. Francis Collins showed at the ACTS meeting in 2015 an article written by him in 1991 regarding titled Physician-Scientists: A Vanishing Breed in which he talks about the vanishing researcher and this income discrepancy.<sup>10</sup>

Dr. Christopher Austin, Director of NCATS, frequently emphasizes that we need a way to train and maintain careers of all researchers, whether they be full time principal investigators or team players who do mainly clinical work but serve as co-investigators on trials. Analogies can be made to other fields, such as the quarterback and linebackers in football, or the conductor and 2<sup>nd</sup> violinist in a symphony, or the prima ballerina and sugar plum fairies in ballet. It is a challenge for both the leaders and essential team members to train and then remain involved in CTR.

#### **Barriers/Essentials to doing Multi-Center Trials: Team Approach**

*'No man is an island, Entire of itself, Every man is a piece of the continent, A part of the main. If a clod be washed away by the sea, Europe is the less. As well as if a promontory were. As well as if a manor of thy friend's Or of thine own were: Any man's death diminishes me, Because I am involved in mankind, And therefore never send to know for whom the bell tolls; It tolls for thee'.*  
– John Donne

A large team is required to conduct a clinical trial whether single site or multi-site. Team members needed include but may not be limited to: principal investigator, co-investigators for each site (blinded and unblinded), project manager, study coordinators, clinical evaluators, biostatisticians, data manager/informatics, research pharmacy, laboratory/radiology personnel, budget/contracts, Internal Review Board (IRB), Data Safety Monitoring Board (DSMB)/Safety Monitors, patient advocacy groups, patients (to serve on study design and implementation committees) and external monitors. It is daunting to gather all of the team members, but just as daunting is coming up with the finances to pay for the team.

#### **Barriers/Essentials to doing Multi-Center Trials: Sites on Team**

Another barrier that is essential to overcome is determining which sites will be members of the study team. Many clinical trials require multiple sites, especially in rare disease research (the focus of our research), in which recruitment is a challenge due to the rarity of patients. Those sites chosen will become the sites in the trial where patients will be enrolled and placed on the study drug and followed throughout the study. As a leader of a multicenter trial, it is important to learn how to find and choose sites.

On a current study that we are recruiting for, Patient-Assisted Investigation of Neuropathic pain: Comparison of Treatments in Real-Life Situations, we need to utilize up to 40 sites to aid in recruiting 400 patients with painful neuropathy. Sites should be chosen based on if they have the patient population, and



whether their research team is willing to recruit. We are often asked how a PI in Kansas can find sites to ask to be in a trial. This is not an easy question to answer but predominantly this is due to networking through academic societies where one becomes familiar with investigators over time. A site may get in a study and can demonstrate how well they perform in recruitment and regulatory efforts and if they do well, they will be asked back to future studies.

Another tool to aid in choosing sites is to become a member in a consortium. At KUMC, we currently are a member of the following consortia: Greater Plains Collaborative and the Vasculitis Patient Powered Research Network (both funded by PCORI), NeuroNEXT (funded by NIH), Alzheimer's Disease Cooperative Study (funded by NIA), Neurological Emergencies Treatment Trials and the NIH StrokeNet Nation Clinical Coordinating Center (both supported by NIH/NINDS). We are also a funded site of the National Cancer Institute. By becoming a member of a consortium, it allows you to gain a foothold in conducting clinical trials. Your experience will become a known commodity and more likely to be asked to participate in non-consortium trials.

#### **Barriers/Essentials to doing Multi-Center Trials: Regulatory**

A major barrier that must be overcome is the handling of the regulatory issues faced in every study. Most of the issues are FDA regulatory issues. As the Principal Investigator (PI) at a site and the lead PI for the study, you are ultimately responsible for what occurs at

each site. You must follow FDA guidelines. For instance, do you need to apply for an Investigational New Drug application or can you do the study under exempt status? The rules for this are available through the FDA.<sup>11</sup> If you do apply for an IND, the FDA has to respond within 30 days. If they do not respond in 30 days, you can proceed with the study. If they do respond, you will most likely need to modify the protocol per their request. In most cases acknowledgement from the FDA is required before submission to the IRB is allowed. If you obtain a FDA IND, you have to file an annual updated with the FDA.

Another barrier that is essential to overcome is handling IRB approval from each site. Depending upon the study and the sites chosen to participate in the study, each site may have to submit to their own IRBs for approval. Recently there have been strides made in utilizing a single IRB on multicenter trials and there is a huge momentum at the NIH and PCORI levels to utilize a single IRB.<sup>12</sup> There are several proposed solutions to this barrier. First is to utilize a Central IRB (cIRB). This has been utilized in industry for some time with commercial central IRBs but academic centralized IRBs are new. cIRBs generally focus on particular topic or disease (e.g., NeuroNext, NCI CIRB). A second option could be utilize a commercial IRB (e.g. Western IRB). These are often used for industry-sponsored multi-center trials. A third option is to utilize an IRB Share agreement. This is a joint review model and "Shared Review Process" in which a lead IRB approves a study; the Local Oversight IRB verifies agreement with the determination of the

Lead IRB, and reviews local context issues. The fourth option is to utilize a Reliance model. This is a single IRB of record, chosen on a study-by-study basis, for the life of a study, involving a “reviewing IRB” and “relying institutions”. The PCORnet Greater Plains Collaborative utilizes this model.

In a multicenter study the protocol must first be approved at the coordinating site, i.e. the IRB of record. Once it is approved, it is then sent to the other participating sites. The IRB of record will need to approve the consent forms from the participating sites prior to site activation. Once the participating sites are activated, they may begin enrolling study participants. The primary site acting as the IRB of record will track annual IRB approvals and track all adverse events and serious adverse events at all sites.

#### **Barriers/Essentials to doing Multi-center trials: Monitoring**

Pharmaceutical companies routinely do FDA compliant monitoring. This involves having a monitor periodically go through the research files on subjects enrolled in studies to ensure all proper research procedures are being followed. FDA released a White paper in 2007 titled The Food and Drug Administration’s Oversight of Clinical Trials (OEI-01-00160) which found that investigators conducting investigator initiated studies were deficient at monitoring their studies.<sup>13</sup> There has recently been a push by the FDA for investigator-initiated studies to monitor their studies. Since then, the FDA released a draft guidance in 2013 that provides guidance for monitoring titled ‘Oversight of Clinical Investigations- A Risk-Based Approach to Monitoring’.<sup>14</sup>

The barriers to monitoring include supporting the infrastructure to carry out the monitoring, which includes personnel and the finances to hire them. Whereas pharmaceutical companies have the financial resources to carry out monitoring, investigator initiated studies using federal or other funds do not. The budgets for investigator initiated studies rarely have the capacity to fund a robust monitoring program. What we have done in our studies is a compromise so that we do remote monitoring and have sites send a selected number of study records for review. If they are deficient, a higher level of monitoring can be activated.

#### **Barriers/Essentials to doing Multi-center trials: Recruitment**

##### **Frontiers Registry**

No investigator initiated study will succeed if you cannot recruit the subjects needed for the study, making this a major barrier. At the University of Kansas Medical Center, we have arrived at some very innovative solutions. The Frontiers registry was developed out of our NIH CTSA program. All patients seen in a KUMC clinic are asked to sign up so they can potentially be contacted to be a research participant. As of January 2015, the Frontiers Registry contains nearly 40,000 potential research participants that were acquired from 17 different participating KUMC clinics. Use of the Registry has continued to grow and has been used by 49 different investigators (24 MDs and 25 PhDs) for 64 different protocols, a 50% increase over the last year. A variety of departments are using the registry spanning KU-Wichita, KU-Lawrence and UMKC. A total of 14,051 contacts have been provided to investigators. Of these,

3423 were contacted by investigators resulting in 188 participants enrolled in studies. This experience was recently published by Dr. Kluding and colleagues from Frontiers.<sup>15</sup>

### Pioneers

Another solution we have developed is the Pioneers Community Research Recruitment Registry, which also was developed in our NIH CTSA Frontiers program. The Pioneers Community Research Recruitment Registry was launched in September 2013. The Pioneers registry is an online, community-based research participant registry that can be used by investigators from multiple institutions within the Frontiers network. There are 2 primary objectives of the Pioneers Registry program: 1) to provide a universal portal for anyone in the community to “Become a Pioneer” and agree to be contacted for future research; 2) to provide an interactive website for listing studies that are actively recruiting participants.

Investigators may utilize the Pioneers program not only to advertise their study, and to request names and contact information for potential research participants using the results of a general medical history survey, but they may also include an interactive “I am interested” button in the description of their study. This allows potential participants to contact the study team directly, and may also include study-specific screening questions. These features were launched in Spring 2014 and are available to investigators to support their recruitment efforts.

### HERON

The third solution is the Healthcare Enterprise Repository for Ontological Narration (HERON). HERON is a repository of de-identified clinical and biomedical data for clinical and translational research. HERON allows users to explore clinical data from multiple sources, housed in our EMR (Epic). Heron queries

Table 1: Complementary Recruitment Programs in Frontiers

	<b>Frontiers Registry</b>	<b>Pioneers Registry</b>
Status	started in 2009; approximately 40,000 people	started Sept 2013, currently 541 people and 179 active studies listed
Participant source	U Kansas Physician Clinic Patients only	Anyone
Enrollment	Via UKP Clinic Registration; paper	Via website
Link to EMR?	Yes	Optional
Access to registrants	KUMC researchers only	All Frontiers partners (e.g. KUMC, Children’s Mercy, St. Luke’s, UMKC)
Ways to contact registrants	Phone or mail; email for those signed up since Sept 2014	Email, phone, or mail

can provide a count of how many patients at KUMC meet the criteria of a clinical trial, and can provide additional patient observational data. HERON is linked to the Frontiers Research Participant Registry so that patients identified through HERON that participated in the registry can be contacted.

#### **Barriers/Essentials to doing Multi-Center Trials: International Sites**

Conducting clinical trials within the border of the United States can be challenging. Adding sites outside of our border adds an additional layer of complexity that few clinical investigators are aware of. For instance, if you have a site in Canada, you have to submit to Health Canada prior to the site initiating the trial. Health Canada is the Canadian version of the FDA IND. There are differences in terminology that we face with the application. Also, there is additional paperwork few US clinical investigators know about when transporting drug across the border for research. This information can be found at [http://www.hc-sc.gc.ca/dhp-mps/compli-conform/import-export/gui-0084\\_biu-uif-eng.php](http://www.hc-sc.gc.ca/dhp-mps/compli-conform/import-export/gui-0084_biu-uif-eng.php).<sup>16</sup>

Europe adds an additional barrier. There are European Union regulations that try to unify regulatory process for studies across Europe. However, each country often has their own additional requirements. One of the most expensive barriers to using a site in Europe is the need to hire a Qualified Person (QP). This person is hired to inspect the locations where the drug is processed. For instance in our mexiletine study, the QP not only had to inspect the drug manufacturing plant in Israel, but also had to inspect where the drug and placebo were over-

encapsulated (University of Iowa's Research Pharmacy). There had to be separate contracts with the pharmacy, data coordinating center, as well as with the University of Kansas Medical Center. Medication had to be shipped from the University of Iowa's Research Pharmacy to a holding pharmacy where it had to be labeled. At that point, it could be shipped to the appropriate sites within Europe. Last but not least, customs at times would not release the drug pending a customs fee.

Using international sites is expensive for a budget on an investigator initiated trial and this needs to be factored into the budget. On the other hand, these international sites may be essential to meet enrollment needs for a study. We could not have completed our positive mexiletine in non-dystrophic myotonia study without the partnering of the Institute of Neurology in London, England, the University of Milan in Milan, Italy and University of Ontario in Canada.

#### **Conclusion**

There are significant barriers in carrying out a multicenter trial as the coordinating site. These barriers can be overcome but it takes personnel, infrastructure, time, training and money. Leading a multicenter study takes knowledge and skill and may not be for the timid or weak at heart. But the rewards are great and if you can overcome these many barriers discussed here, you and your team can have a significant impact in CTR and become leaders in your field.

Acknowledgements: We would like to acknowledge funding by a Clinical and Translational Science Award from NCATS at NIH, UL1TR000001; a Clinical and Data Research Network award from PCORI as part of the PCORNet initiative, CDRN-1306-04631; a NeuroNEXT award from NINDS at NIH, U10NS077356; and a comparative effectiveness research project award from PCORI, CER-1306-02496.

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# Nebraska Innovation Studio: A University-Based Makerspace

**Shane Farritor, David and Nancy Lederer Professor, Mechanical and Materials Engineering, University of Nebraska**

The University of Nebraska-Lincoln is creating a new makerspace called Nebraska Innovation Studio. Makerspaces are a growing trend across the world and some precedent for University makerspaces exists. A makerspace (sometimes referred to as a Fab Lab, Hobby Shop, or Hacker Space) is a community-oriented physical space where students and other members can build and create. The focus of a makerspace is on creativity, interdisciplinary collaboration, entrepreneurship, and education.

Students from across campus and all community members will be allowed to join the Nebraska Innovation Studio and build their own original projects. Nebraska Innovation Studio is a both a physical space and a community. The physical space contains specialized tools and equipment (3D printers, laser cutters, computer controlled embroidery machines, machining centers, etc.) along with collaboration space that will allow students to create projects that they are passionate about. The community will provide specialized classes that will enable the students to physically realize their own innovations. These non-degree classes will expand and improve the student's education by allowing them to learn by doing. This experiential education will better show our students that the world is out there to be engaged and shaped.

UNL is creating Nebraska Innovation Studio for several reasons:

- It will strongly contribute to the dynamic multi-disciplinary innovative culture that is a goal of UNL.
- It will allow for innovative experiential student learning. Disciplines from Electrical Engineering to Art to Fashion will teach non-credit courses on how to build things. The space and courses will be designed to encourage collaboration and mixing.
- It will foster entrepreneurship. There are multiple examples of new products created in makerspaces across the United States.
- It will be an attractive facility to encourage interactions between the University and the private sector. It will house expertise and equipment to quickly make prototypes to support the "fail fast and learn" model of innovation.

## **What is a Makerspace?**

*The Recreational Center Analogy*

Current Campus Recreational (Campus Rec) facilities are a good analogy to describe a makerspace. Campus Rec is to

fitness what the makerspace is to creativity. Students can join Campus Rec and gain access to specialized equipment (e.g. weight room, gym, pool), collaborate with students with similar interests (e.g. pickup basketball), and take non-degree classes (spinning classes, rock climbing classes). All of this is focused on enhancing the student's fitness. Students are not required to participate, they only come to Campus Rec to pursue their passions and do things they love. They go to Campus Rec to improve themselves. In the same way, students will join Nebraska Innovation Studio to gain access to specialized equipment, collaborate with students of similar creative interests, and take non-degree classes.

The Campus Rec system also organizes activities across campus to encourage fitness. It creates programs for employees to walk over the lunch hour or to lose weight, and organizes Intermural sports. Nebraska Innovation Studio will organize activities to encourage creativity, and can serve the same role with invention competitions and creativity seminars.

*What will the makerspace look like?*

The interior design and layout of the makerspace will be important to foster collaboration and innovation. An oversimplified layout is described here to help explain the makerspace.

The core of the makerspace is an assembly/integration and collaboration space. This is an area where members will gather to put their projects together and in doing so will have the opportunity to interact. Various rooms can then be placed off the main collaboration area for specialized equipment. This arrangement

will encourage interactions as members move from room to room.

The specialized rooms will include space for digital fabrication equipment such as 3D printers, laser cutters, water jet cutters, 3D scanners. A computer area will be provided for CAD programming and interaction with the digital fabrication equipment. Other rooms will include equipment for fabric fabrication such as CNC embroidery. Traditional metal and woodworking machinery will also be included. Other areas including a digital classroom and meeting areas will be needed to support the Makerspace.

### **Why a makerspace?**

There are several important reasons why a world class makerspace is being built at UNL.

#### *The Makerspace Creates Culture*

The first reason to build Nebraska Innovation Studio is that it will help build a culture of innovation. The makerspace will attract students and their energy is the most important ingredient of an innovative university. The students will come to Nebraska Innovation Studio by their choice and to follow their passions. Students can then interact with faculty and community members in a casual environment where common interests are shared.

It is expected that the Nebraska Innovation Studio will spawn other aspects of creative culture. For example, a maker's club has been formed with regular meetings and an annual "Maker's Fair" where members can highlight their latest creation. Studio members then generally subdivide into specialty groups (bike nuts, furniture makers, fashion designers) to further pursue their common interests.

It is strongly believed that there is a latent demand among many, many UNL students for this opportunity to express their creativity and build things. Nebraska students are hands-on problem solvers by our DNA and this makerspace will help develop this tremendous untapped potential.

*The Makerspace Will Foster (Student) Entrepreneurship*

One of the incredibly beneficial side effects of maker culture is that it is an incubator for entrepreneurship and this entrepreneurship will be built around students. It is believed that UNL students represent a huge untapped potential for new businesses and innovation. The maker community and the facility itself in partnership with other efforts at NUTech Ventures and Nebraska Innovation Campus (NIC) will mine this tremendous potential.

Maker culture is full of successful entrepreneurship stories. For example, the Square card reader ([www. squareup. com](http://www.squareup.com)), that allows you to swipe credit cards with your cell phone, was first built in a community makerspace in San Francisco. Access to the makerspace allowed the founders to build a functional prototype they could then use in demonstrations to venture capital groups. This greatly helped them raise funds and got them started building a multi-million-dollar company that simplifies many lives each day. This invention itself can be a great benefit to all other small businesses further enabling entrepreneurship.

Several smaller scale successes are also common. The MIT Hobby Shop (an existing makerspace) is a constant hotbed of startup prototyping. Just to name a few

examples, an undergraduate photography major built her own large format cameras there. She then invented a multi-color LED-based ring flash for specialized photography that is controlled by an embedded microcomputer. This ring flash allows the photographer to dial in the appropriate color for the flash for every picture. She now sells a number of these niche devices through an online business.

A second Hobby Shop startup company was created by a graduate student studying acoustics. This student invented a "speaker dome" that allows museum visitors to stand in front of an exhibit and listen to information about the exhibit without others in the museum being disturbed by the noise. These can be found in several museums around Nebraska. These are simply anecdotal examples of makerspace inspired entrepreneurship.

*The Makerspace Will Support a Business Accelerator*

Nebraska Innovation Studio will support a business accelerator that will focus on hardware-based startup companies. The makerspace will be a major benefit for companies in the accelerator because it will allow them to quickly prototype their products. The proximity of the accelerator and the makerspace will increase the quality of companies that apply for the accelerator, potentially attracting companies to Nebraska. As stated before, the makerspace would act as a hub for innovation and creativity by bringing together people from the business accelerator, UNL faculty, students, and staff, and local business.

Successful startup companies often constantly iterate on prototype designs of their products, as suggested by new



methods of innovation such as Steve Blank's Lean Launch Pad (LLP). For example, an innovative start-up company such as Dyson created over 1,000 prototypes before it created the vacuum cleaner it took to market. Without the makerspace, the process of design iteration can take days or weeks when 3rd party vendors are used for fabrication. Having prototyping capabilities in-house (i.e. in the makerspace), will allow entrepreneurs to turn what can take days into hours, speeding the process and allowing startups to achieve more in less time. This quick design-iterate-feedback cycle has sociological benefits for the startup by allowing it to:

- achieve more and demonstrate more,
- build momentum and give them more control
- create a more positive and enjoyable experience
- reach a marketable product quicker

Overall, the makerspace when combined with a business accelerator will produce more investable companies, with an increased probability of success.

### **New Skills Are Required for the Quickly Changing World**

*Cross-Disciplinary Skills Are Now Required*

Another important reason to create a UNL student makerspace is that new skills are required for a changing world. This will mean that we need to change the way we educate our students. Skills that used to be valuable are either being automated or can be done more cheaply in other countries. For example, stress analysis used to be a valuable skill for a mechanical engineer. Today, stress analysis is either performed with a software program or is uploaded to an India-based

website and a report is emailed back in a few days. Or, legalzoom.com now does many functions attorneys used to charge significant hourly rates to accomplish. What will be valued in the coming economy will be skills like creativity and unique cross-discipline skills such as:

- A fashion designer that knows how to laser cut molds for a production run of 50-100 dresses
- An electrical engineer who can 3D print a custom circuit board enclosure overnight because she doesn't need to coordinate with 3 other departments to get this done.
- An artist who can use an Arduino microprocessor to control an installation piece based on the position of the person observing the work

Nebraska Innovation Studio will produce these kinds of students with cross-disciplinary skills.

Hands-on courses will be taught at the makerspace. For example, the Mechanical Engineering Department might teach a freshman course there like "How to build (almost) anything" for their own students and/or for students from fashion design. However, it is expected that most courses will be taught by makers for makers. For example, a computer science student might waive his membership fee by offering a course like "Introduction to Programming the Arduino Microcontroller" in the evenings.

Again, the makerspace is NOT a traditional machine shop where you pay someone else to build your design. The makerspace is where YOU LEARN by creating your own design and by collaborating with and learning from your peers.

It is strongly believed that there is a latent demand among many, many UNL students for this opportunity to express their creativity and build things. Almost all makerspaces that are built are almost instantly oversubscribed.

The makerspace will also host an online forum where students can post about their designs and activities. This will help build a community and collaboration where others can build on the designs and best practices of their peers.

*Customization is Now Free*

The world of product design and manufacturing are dramatically changing with the advent of new digital manufacturing technologies. The result of these digital technologies is that customization is now free.

The twentieth century of manufacturing was about the assembly line and increased access to goods through producing large numbers of identical units at the lowest possible cost (e.g. you can have any color Model T as long as it is black). Cheap labor, low regulation and little concern about the environment favor other countries in manufacturing ten million identical units at minimal cost. However, new technology such as 3D printing allow for customization and automation of manufacturing and open new niche markets that are not realistic for the assembly line model of manufacturing. Many believe these new technologies will lead to a new world of “desktop manufacturing” and “democratized manufacturing” where anyone can make a small number of extremely custom products. In this new model students from all disciplines will need to know how to create products that are specifically customized to individual needs.

New technologies such as 3D printing, and other desktop manufacturing technologies, are analogous to the 2D desktop printing technology that has become common over the past 30 years. Current 3D printers are crude and limited like old dot matrix printers of the early 80’s. However, today, we all have our own \$75 ink jet printer that can create top quality photographs or print our airline tickets with a custom bar code. Future 3D printers will allow us to “print” our own products at our desktop just like we print our own family photos today.

Imagine the future of 3D printing and manufacturing. Today, if you want to buy your child some doll house furniture, you can go to a place like Walmart where there are a few choices of mass produced products. In the future, you might instead download some designs from a hobbyist furniture designer in Sweden, add your child’s name to the product, and change the colors so they match the furniture in your own home and then 3D print the doll house furniture from your desktop. This desktop manufacturing allows for total customization (one size fits one) design of products. There is no cost to added complexity (adding your child’s name) or customization (changing the color of the furniture). This model will fundamentally change the skills that are needed in the new marketplace (in all disciplines from engineering to furniture designers).

Nebraska Innovation Studio will introduce our students from all disciplines to this new model of customized and niche design and fabrication.

*Experiential Learning at the Makerspace (Mind and Hand)*

Another way the makerspace will enhance the education of UNL students is

that it will provide experiential learning. Students will do as a way to learn. It is in the experience of trying to build that much of their education will reside. They will be better prepared to enter the workforce because they have learned important lessons that can only be taught thorough doing.

The lessons learned by doing are differently into a student's brain because of the difficulty they presented and the physical actions required to solve the problems. This is different than missing five points on the forth problem of third exam in a course.

Also, lessons are learned that are generally not taught in class. Students will learn about real-world problems such as shipping delays or how to clamp

a part while it is being machined. These lessons will again better prepare them to enter the workforce.

### **Summary**

The University of Nebraska is creating a makerspace called Nebraska Innovation Studio. The makerspace is a physical space full of equipment that will allow students to build projects and explore their creativity. The space will help build a creative culture that will lead to innovation. Nebraska Innovation Studio will foster a different kind of learning as student involvement will be from intrinsic motivation. The makerspace will help foster entrepreneurship and will encourage cross-disciplinary collaboration. This effort is just beginning at UNL, please look back to check on our progress.

# Creating and Sustaining Interdisciplinary Research Groups

Mary Rezac, Tim Taylor Professor of Chemical Engineering,  
Kansas State University

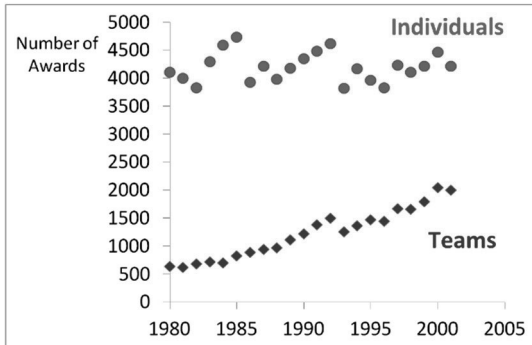
**M**ultidisciplinary research projects are becoming increasingly common within the realm of academic research. Data suggests that more than 50% of projects funded by NSF and at one major research institution would be included in this category. As academic institutions transition from single PI research projects to teams of researchers from numerous departments and colleges, new issues relating to fund distribution, credit accounting, and team leadership become apparent. Here, we examine the trends in multidisciplinary research projects, the perceived barriers to their success, and recommendations to overcome these barriers.

*Interdisciplinary teams develop more complete solutions to societal problems.* The National Academy of Engineering has identified 14 critical areas of societal importance that require concerted effort in research, development, and public policy if they are to be successfully addressed.<sup>i</sup> These topics range from making solar energy economical to providing access to clean water to reverse-engineering the brain. The common thread among the topics is that they are interdisciplinary and complex. If solutions to these problems are to be found, engineers must be involved. Yet, engineers working in isolation will almost certainly fail. Rather, they must engage with researchers from agriculture, medicine, public policy, economics, physics, biology, and numerous other fields. This trend toward larger and more complex research problems has been observed for the past two decades.

*Funding agencies are shifting their support to interdisciplinary projects.*

While complete and precise information about the nature of funding provided by the federal government to interdisciplinary research projects is not immediately available, anecdotal information suggests that funding agencies are shifting their support to interdisciplinary projects. Information relating to the research funding supplied by the National Science Foundation is publically available<sup>ii</sup> and can provide some insight into this agencies' tendency in this matter. **Figure 1** provides the number and value of awards made by the National Science Foundation from 1980 through 2003. In both cases, if a project was awarded to a single principal investigator, that project was counted in the "individuals" category. If the project had two or more co-PIs or a PI with one or more senior personnel identified within the award document, the project was counted in the "team" category. It is interesting to note that the number of awards made to indi-

viduals during the study period remained roughly constant at about 4500. In contrast, the number of awards made to teams increased by a factor of four over this same period. At the end of the study



**Figure 1:** Research projects supported by the National Science Foundation for fiscal years 1980 – 2003. Team projects are those with two or more investigators of any title.

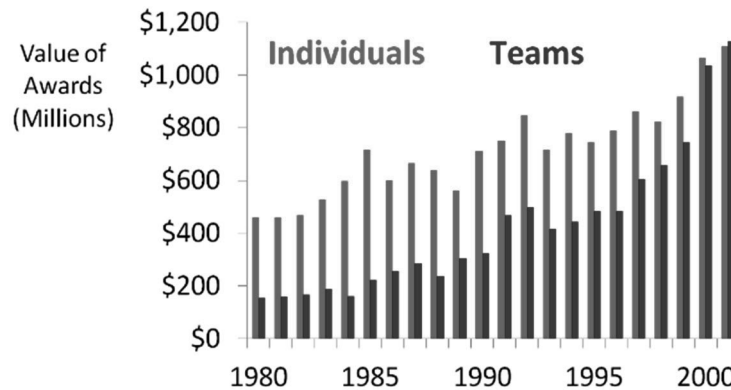
period, the number of grants made to individuals remained approximately twice that made to teams.

When the value of the NSF grants is considered (**Figure 2**), an even more striking argument for the importance of team activities is observed. During the study period, the total value of all awards made by NSF to individuals increased from approximately \$450M to \$1,100M. Thus, the average value of awards made to individuals increased from \$100,000/grant to

\$245,000/grant. In contrast, the team awards increased at a much faster rate, from \$180M to \$1,150M with average awards increasing from about \$300,000/grant to \$575,000/grant.

Thus, it is clear that from NSF funding trends, both the number and value of projects awarded to research teams have increased dramatically in the past decades. If academic research institutions are to compete successfully for these funds, they must support their faculty members and research staff in the development of functional and efficient research teams.

More detailed information is available from an analysis of research completed at the University of North Carolina, Chapel Hill. This information looked at the total research funding and the categorization into projects that included more than one investigator, principal investigator, or lead principal investigator.<sup>iii</sup> This data is presented in Figures 3 and 4. As is the case with many institutions, research funding has increased over the period of 2008 – 2014 with a significant uptick in 2010 as a result of ARRA funding. For UNC, the 2014 funding level was approximately 18% larger

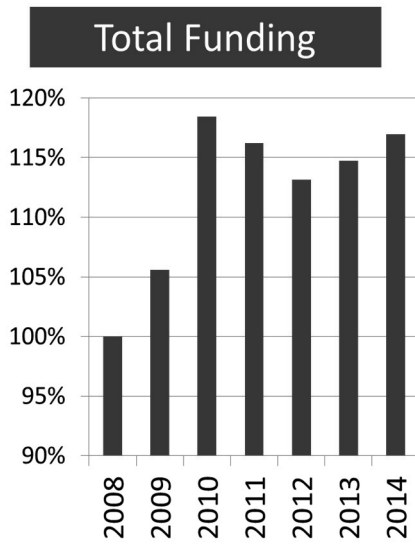


**Figure 2:** The total value of research projects supported by the National Science Foundation, 1980 – 2003.

than the 2008 base. Concurrently, the nature of the project leadership teams was also changing. During this entire period, over 55% of the funded projects at UNC were lead by teams of researchers. Nevertheless, the breadth of the knowledge and expertise of the project leaders appears to be increasing from 2008 to 2014. In Figure 4, one observes that the percentage of projects with research leaders from more than one department increased from 15 to 45% and the cross-college collaborations increased from 12 to 25%. Marked increases in both of these categories is noted in 2010 with relatively constant behavior following. This suggests that the broadening of research team leadership may be related to requirements that were made by the federal gov-

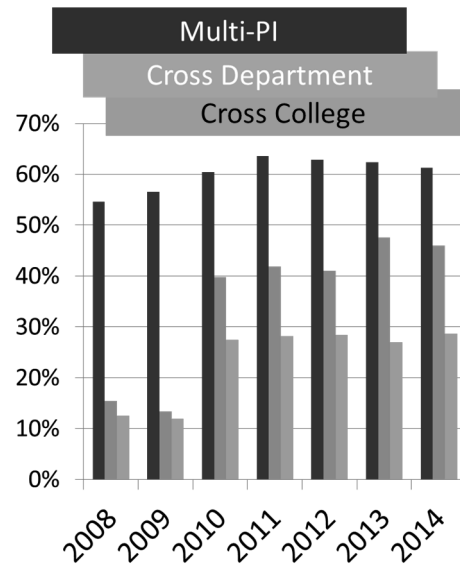
Analysis of the data indicates that funding agencies are supporting multi-disciplinary projects and researchers at successful institutions are shifting to these team-lead projects. Yet, not every researcher has or will navigate the transition to being a productive member of an interdisciplinary team. Why?

*There are real and perceived barriers to multi-disciplinary research within academia.* While society, funding agencies, and university administrators may be encouraging faculty members to conduct research projects as a member of a multi-disciplinary team, that transition can be difficult. In a 2004 study entitled *Facilitating Interdisciplinary Research*, the National Academy of Engineering concluded that there are multiple barriers to success of these research teams.<sup>iv</sup> In a survey of successful academic researchers and re-

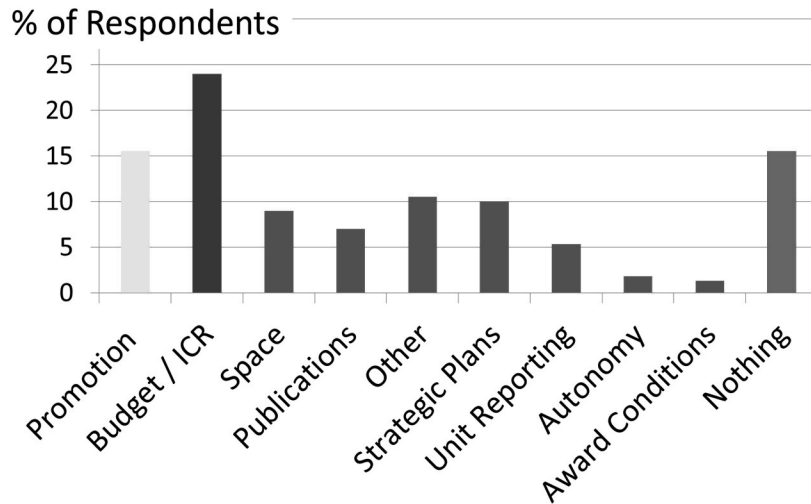


**Figure 3:** Total research funding at UNC, Chapel Hill, 2008 – 2014. The significant increase in funding in 2010 is the result of additional funding from the American Recovery and Reinvestment Act of 2009. 2008 Funding = \$678M.

ernment as a part of the 2009 ARRA funding initiative. If the ARRA funding was the motivation for this shift, the result seems to have outlived the program.



**Figure 4:** The nature of research funding at UNC, Chapel Hill, 2008 – 2014. Projects are identified as having multiple investigators (dark blue), investigators from two or more academic departments (grey), and investigators from two or more colleges (green).



**Figure 5:** Perceived barriers to multi-disciplinary research projects. Graphics adapted from NAE *Facilitating Interdisciplinary Research* Report.

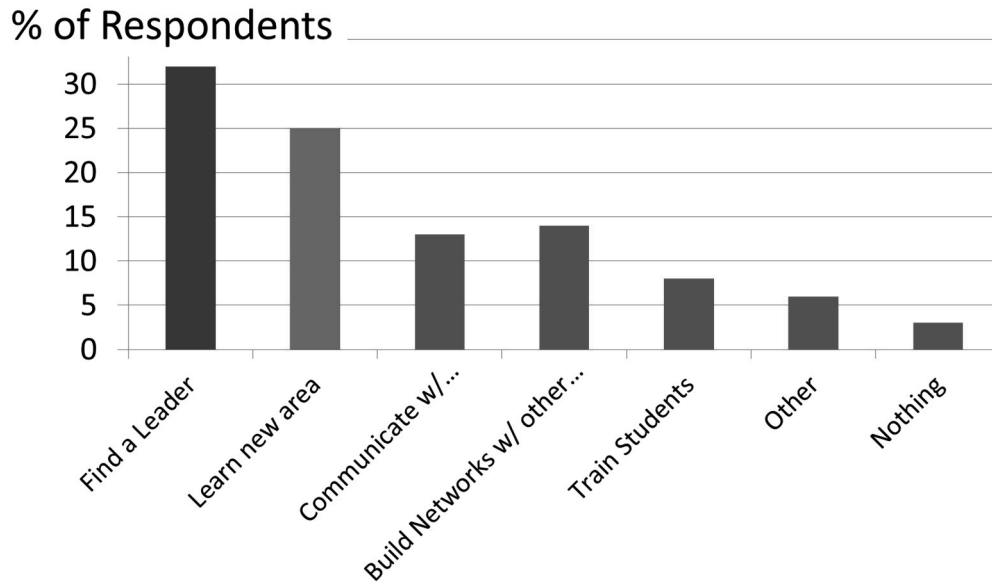
search administrators, the items identified in Figure 5 were deemed to be the biggest barriers to success of multi-disciplinary research projects. The categories, from left to right, are more completely described as: concerns with receiving appropriate credit in promotion and tenure decisions, concerns relating to control of the research budget and/or allocation of indirect cost returns, lack of adequate space to complete the project, concerns with receiving appropriate credit for multi-author publications, other – five separate items each of which received no more than 3% of the votes, concerns with lack of alignment of project with unit strategic plans, concerns with each contributing unit receiving appropriate credit for activity, concerns with loss of individual researcher autonomy, concerns with receiving appropriate credit for award consideration, and finally, ‘nothing’ indicating that the respondent felt that there were no major barriers to interdisciplinary research activities.

Of the 14 categories evaluated, only three individually received more than 15% of the votes. Combined, the three top

scorers received nearly 55% of all votes. These are (1) budget/indirect cost return, (2) nothing, and (3) promotion. Perhaps reassuringly, ‘nothing’ was the second most common result. This suggests that in this 2003 survey, faculty members had already come to the conclusion that there were few actual barriers to team research success. As the number and magnitude of team projects has continued to increase in the past decade, we can only assume that this category will continue to dominate the feelings of faculty researchers.

It is interesting to note that the majority of the concerns relate to allocation of credit whether it be for considerations of promotion and tenure, publications, awards, or unit productivity. It would seem that active work to create a university culture that promotes and rewards members of interdisciplinary teams could go a long way to overcome these fears.

The NAE study also surveyed principal investigators on what recommendations they would make to peers to facilitate interdisciplinary research projects. Results of this survey are summarized in



**Figure 6:** PI recommendations to peers on the single most important step they can make to facilitate multi-disciplinary research project success. Graphics adapted from NAE *Facilitating Interdisciplinary Research* Report.

Figure 6. Again, the y-axis indicates the frequency of response while the x-axis provides the dominant category. From left to right, the categories were: find an individual willing and capable of leading the team project, learn about the new scientific area into which you are entering, communicate with others outside your field to identify potential collaborators, build networks with others outside your field to find potential collaborators, train students in the new topical area, other – five categories none of which exceeded 2% of the vote, nothing/no recommendation. *Based on these options, PIs believed that the single action to promote success was identification of a team leader.*

The leaders identified are not simply the individual with the most in-depth knowledge of the subject area. Indeed, in these multidisciplinary projects, several team members may have equally deep, but differently focused subject area expertise. Rather, the leader that is required is an individual with sufficient subject

area expertise to garner the respect of her or his peers while simultaneously having the managerial, organizational, motivational skills to identify, recruit, promote, facilitate, and finance a research team. These skills can be at odds with the elements of success that have been promoted throughout a faculty member's independent research career and, thus, are not always naturally present in any given member of the research team. Furthermore, when one considers the reward system historically utilized by academic institutions, one can understand why few have voluntarily migrated to this position. Indeed, when academics are rewarded on number (publications, invited seminars, students advised, researcher dollars received), activities which detract from these metrics are understandably minimized. Faculty members are clear in their analysis that leadership of interdisciplinary teams has negative consequences on short-term productivity. Obviously, individuals who have short-term



evaluations (like promotion and tenure) will avoid these leadership positions.

That leaves only the camp of full professors in a position to effectively lead large, multi-disciplinary research teams. Yet, now 10 or more years into their careers, they may have received little or no training on how to succeed in this role. Ah, the quandary.

If we are to transition to this new era of interdisciplinary research team success, our organizations must develop mechanisms for identify, training, and truly rewarding team leaders. The options on the type of rewards are as numerous as the number of team leaders identified. Yet, a few mechanisms are provided for consideration: (1) provide an indirect cost return system that financially rewards the leader of a team project; (2) provide central support for personnel to support large, team projects with the completion of the reports and data collection frequent in these projects; (3) provide central support for evaluation of large, team projects; (4) develop and finance a university-wide research award that focuses on success as a team leader; (5) identify faculty members at all ranks with the skills and inclination to be successful team leaders – provide members of this group with mentoring, and local and external professional development training to improve their skills; (6) recognize the role of team leader in publicity and marketing materials. These are but a

few of the ideas of how one might recognize and support those faculty members who have and will serve in leadership roles within multidisciplinary projects. No matter how it is accomplished, it is imperative that individuals who have voluntarily accepted the leadership role and have been successful in that role be rewarded, recognized, and encouraged to continue in this pattern. Supporting a good team leader is much easier than developing a new one.

Acknowledgements: I thank Mabel Rice for her kind invitation to be a part of the 2015 Merrill Conference and Evelyn Haaheim for making the experience so enjoyable. Several of these opinions are a result of extensive discussions with Loretta Johnson and Stacy Hutchinson at K-State. I am thankful to them for taking time to talk to me about these issues.

### **Cited Works**

- <sup>i</sup> W. Perry, et al., *Grand Challenges for Engineering*, The National Academies Press, 2008, available at [www.engineeringchallenges.org](http://www.engineeringchallenges.org)
- <sup>ii</sup> [www.nsf.gov/awardsearch](http://www.nsf.gov/awardsearch)
- <sup>iii</sup> [Research.unc.edu/about/facts-rankings/research-funding](http://Research.unc.edu/about/facts-rankings/research-funding) Note, it is not clear precisely how ‘research funding’ has been defined. It appears to include research expenditure data but may be based on research awards.
- <sup>iv</sup> Committee on Facilitating Interdisciplinary Research, *Facilitating Interdisciplinary Research*, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 2004, ISBN: 978-0-039-09435-1

# Cuts and Guts: Public University Budget Hemorrhages

Don Steeples, Interim Dean, College of Liberal Arts and Sciences,  
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It is universally recognized that the cost of public higher education across the United States has skyrocketed in recent decades. Post-secondary education expenses, primarily the cost of tuition have become less affordable for much of the population. This paper begins with a direct comparison of the cost for a semester of tuition in 1963 vs 2015. For purposes of this comparison, I have drawn upon my experience as an undergraduate engineering student at Kansas State University, where I first enrolled in 1963. Trends in state support for public higher education in Kansas are reviewed, as are changes in the level of state support nationwide. After this brief review of tuition costs and legislative support, I suggest a few conclusions can be drawn.

## “Old-Geezer” College Tuition Expenses Vs Today

Since I enrolled at Kansas State University as a freshman in 1963, I am qualified to adopt the moniker, “Old Geezer.” **Table 1** (My Geezer’s Experience) illustrates how tuition and residence hall costs at my alma mater have increased since I was a freshman in 1963. My tuition in 1963 was \$107 for 17 hours of engineering courses. When adjusted for inflation,

those 17 hours would cost me \$832 in 2015 dollars. In contrast, the actual cost in fall 2015 at KSU will be \$4,660, an increase of more than five times the inflated cost. Similar results could be shown for The University of Kansas and many other public institutions.

While tuition costs at KSU have climbed over 4000% since 1963, residence hall living remains affordable for most segments of the population: the cost of

**Table 1**

**My Geezer’s Experience**

**Tuition & Housing Expenses at K-State: 1963 vs 2015**

	1963 actual cost	1963 \$\$ inflated to 2015 \$\$	2015 actual cost
<b>Tuition (17 hours)</b>	<b>\$ 107</b>	<b>\$ 832</b>	<b>\$ 4660</b>
<b>Res Hall (20 meals/wk)</b>	<b>\$ 600</b>	<b>\$ 4663</b>	<b>\$ 4215</b>

**Table 2**

### Minimum Wage Comparison

**US Minimum wage:**

1963 \$1.25/hr  
2015 \$7.25/hr

**Hours of work at minimum wage to provide 2 semesters of tuition plus room & board at KSU:**

651 hours in 1963 (~16 weeks)  
1,868 hours in 2015 (~47 weeks)

room and board at K-State has increased at a rate *lower* than general inflation. As shown in Table 1, inflation-adjusted 2015 residence hall rates were more than \$400 *below* the 1963 rate in current dollars. Residence hall rates remain a bargain relative to tuition at public universities in Kansas.

A closer look at decreased affordability is shown in **Table 2** (Minimum Wage Comparison). The minimum wage in the U.S. was \$1.25 per hour in 1963 and in 2015 has increased to \$7.25 per hour. In 1963, a student who worked for 651 hours at minimum wage could earn enough

money for two semesters of tuition and of residence hall living at KSU. In 2015, a student would have to work 1,868 hours at minimum wage to provide for two semesters of tuition and residence hall living. Consequently, it is no longer possible for a student to pay for all of the costs of a KSU degree with a minimum-wage summer job combined with a few hours per week of part-time employment during the school year.

One of the reasons that residence hall living has remained affordable is that the cost of food in the U. S. has risen much

**Table 3**

### Bushels of Wheat Required to Pay for One Semester of Tuition at KSU

<b>1963</b>	<b>55 bushels</b>	<b>@ \$1.94 / bu</b>
<b>2015</b>	<b>1022 bushels</b>	<b>@ \$4.56/ bu*</b>

\*Cash price Hays, KS, 10AW, 8/16/15

more slowly than inflation. My own undergraduate education at KSU was financed by selling wheat from a piece of land that my father let me farm when I was in high school. In 1963, selling 55 bushels of wheat at the national average local-elevator price would provide one semester of tuition at KSU. Based on the cash price for wheat in Hays, Kansas, at 10:00 AM on August 6, 2015, paying for one semester of KSU tuition would require more than a thousand bushels of wheat (Table 3, Bushels of Wheat...). While residence-hall living is a bargain

relative to tuition, wheat is even more of a bargain.

### Kansas Public Higher Education Budget Trends

If we look at Table 4 (Kansas Regents and K-12 Funding), we see that in the decade between 2002 and 2012, State General Fund appropriations overall for public universities in Kansas increased by only 4.9%. In that same period, total expenditures from the State General Fund increased by 36.5%, with the largest percentage of increase going to Human Services (100.9%). Looking at Table 5 (In-

**Table 4**

### Kansas Regents and K-12 Funding 2002 vs 2012

State General Fund Expenditures (millions)					
Fiscal Year	Total Expend.	Regents Total	K-12 Education	Human Services	All Other
2002	4,466.1	704.5	2,345.1	770.6	645.9
2012	6,098.1	739.2	3,091.0	1,548.5	719.4
Increase 2002 vs 2012	36.5%	4.9%	31.8%	100.9%	11.4%

*Source: Governor's Budget Reports, Schedule 2.2*

Modified from "A historical perspective of state aid, tuition, and spending for state universities in Kansas" by Dave Trabert and Todd Davidson, Kansas Policy Institute, 2013

**Table 5**

### Inflation, Kansas State Funding, and Tuition Increases, 2003-2012

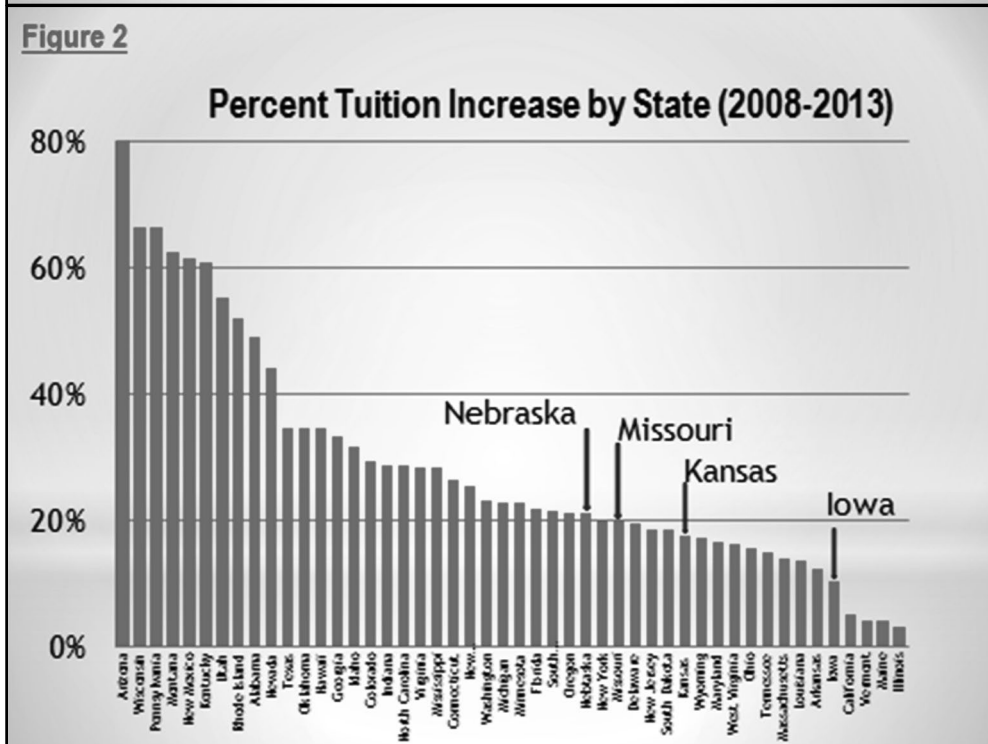
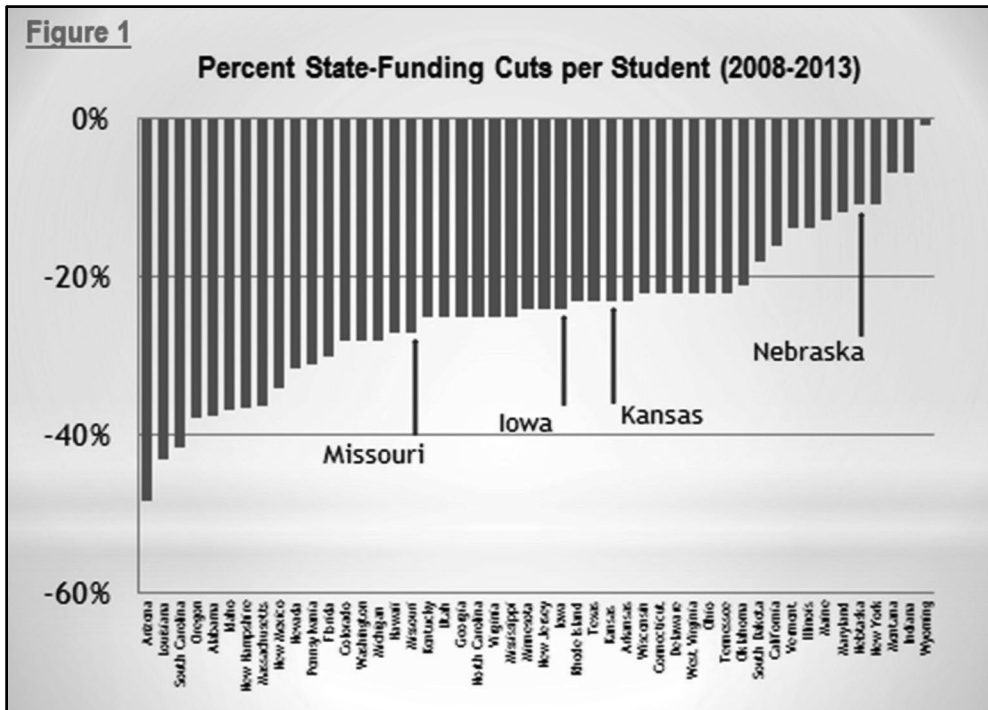
Fiscal Year	Inflation	KBOR Aid	Tuition increase	
			Univ. of Kansas	K-State
2003	2.0%	-5.1%	20.8%	21.5%
2004	1.9%	0.9%	17.7%	17.9%
2005	2.8%	3.8%	15.5%	14.9%
2006	3.4%	5.4%	14.3%	9.8%
2007	1.9%	1.7%	13.6%	12.8%
2008	3.6%	4.0%	7.3%	7.9%
2009	1.0%	-3.9%	6.7%	6.3%
2010	1.1%	-6.5%	5.3%	3.7%
2011	2.2%	1.4%	8.3%	7.4%
2012	2.9%	-1.1%	5.5%	3.8%
10 years	25.3%	-0.1%	193.6%	170.2%

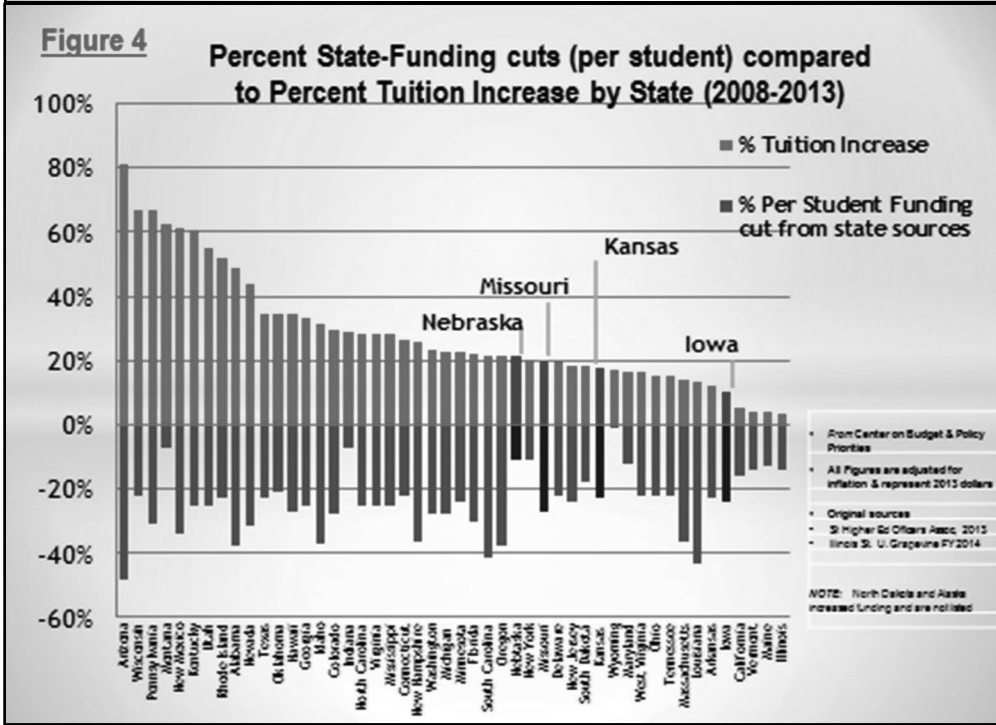
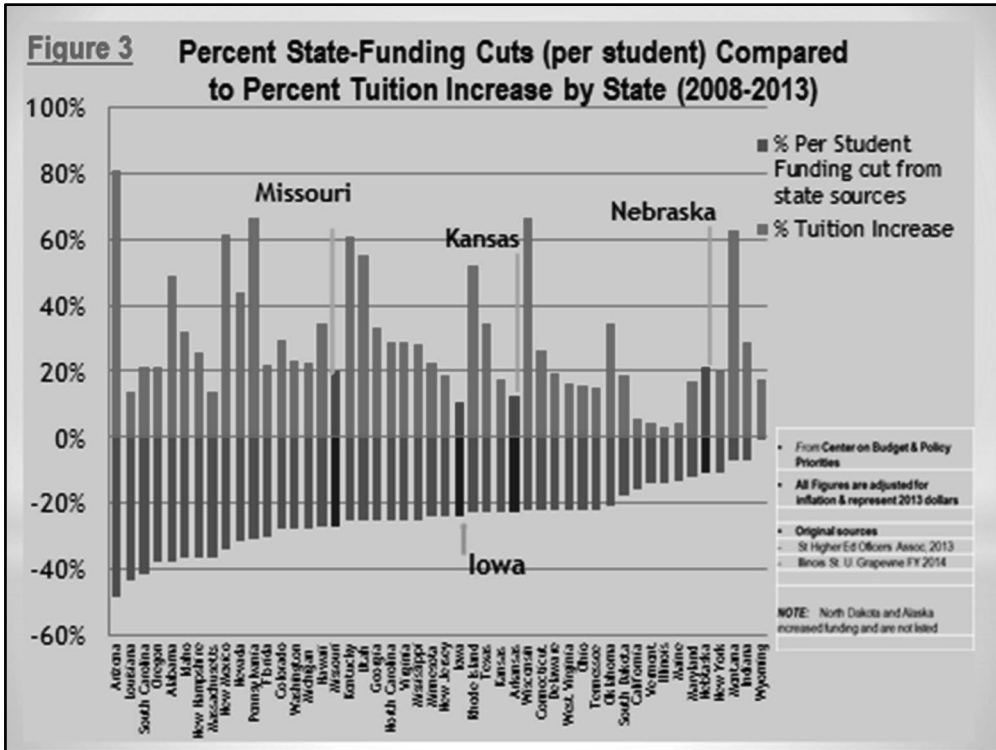
Modified from "A historical perspective of state aid, tuition, and spending for state universities in Kansas" by Dave Trabert and Todd Davidson, Kansas Policy Institute, 2013

flation, Kansas State Funding, and Tuition Increases) we see that from 2003 to 2012, inflation in the U. S. totaled 25.3%. In that same period, State support of Kansas public universities actually decreased by 0.1%. To make up for this decrease in

funding, tuition increased by 193.6% at The University of Kansas and by 170.2% at KSU.

Clearly, the budgets of KU and KSU have been balanced increasingly on the backs of students. Cuts in Kansas state-





government funding have been offset by tuition increases. Based on the Kansas experience, it seemed reasonable to hypothesize that cuts in state-government funding for public universities across the U. S.

have been mostly offset by tuition increases. Let's now examine the degree to which this is true across the whole U. S.

**U.S. Public Higher-Education Budget Trends (2008-2013)**

The funding trends across the U. S. in the period from 2008 to 2013 have varied greatly (**Figures 1-4**). Only two states (Alaska and North Dakota) increased funding per student during the period. In contrast, Arizona, Louisiana, and South Carolina decreased per-student funding by more than 40% between 2008 and 2013. During the same window of time, Kansas, Missouri, and Iowa all decreased per-student funding by between 20-30%; Nebraska decreased per-student funding by about 10%.

As we have seen above, when the Kansas state government reduced funding, the Kansas Board of Regents responded by approving tuition increases that were essentially designed to fill the funding gap. Several other states followed a similar path. For example, Arizona cut per-student funding by about 48% and increased tuition by 80%. Wisconsin, Pennsylvania, Montana, New Mexico, and Kentucky all had tuition increases of more than 60% between 2008 and 2013. (At the opposite end of the spectrum are Louisiana and South Carolina, which cut per-student funding by more than 40%, but only increased tuition by about 14% and 21% respectively.)

Overall, state per-student funding is generally a picture of less per-student public financial support amid tuition increases. The tuition increases may or may

not partially replace, totally replace, or exceed the cuts in public funding.

Declining public financial support for higher education on a per-student basis has led to increased tuition costs in Kansas and surrounding states. In the face of this fact, administrators will be forced to make difficult, but wise, decisions on where to apply budget cuts at their institutions. This will necessitate a thoughtful review of resource deployment...as well as the development of a healthy dose of intestinal fortitude.

## **Conclusions**

*Since 1963:*

1. In Kansas, tuition has risen 5X faster than board and room
2. In Kansas, tuition has gone up 3X faster than the U.S. minimum wage
3. Students can no longer pay for college with just a summer job

*Since 2002:*

1. Kansas' state budget has gone up 8X faster than its support of higher education
2. Only two U.S. states have increased per-student funding since 2008
3. Tuition increases do not necessarily offset decreased state support
4. Decreased state support does not automatically mean tuition goes up

# The American Research University and the Iowa Experience

Daniel Reed, Vice President for Research and Economic Development,  
University of Iowa

**W**e humans are not particularly good predictors of change, particularly exponential change. We tend to extrapolate tomorrow from today, and in the near term, that is a safe and reasonable expedient. However, the pace of change is accelerating, with ever greater global connections and shifting social expectations. Thus, one would be surprised if these economic and social changes did not have equally profound implications for the role and function of the American research university – and they have.

The litany of public higher education woes -- rising tuition and student debt, declining state support, sequestration battered federal research budgets, mounting compliance and reporting burdens, escalating deferred maintenance concerns, and heightened political scrutiny – grows ever longer, framed by shifting societal expectations and a rising chorus of questions about educational value propositions. These public higher education issues must be considered in the broader socioeconomic context.

The lingering effects of the 2008 global recession, rising wage and income disparities in the United States, the European Union's uneasy and politically fraught economic confederation, and the unknowable true state of China's faltering economic growth all cast long shadows. Political instabilities, wars, sectarian and ethnic persecution and violence, and refugee flight define international political debates. Urbanization, global communications, talent mobility, and the global

knowledge economy are reshaping social expectations.

Compounded by the consilience of globalization and the accelerating technological and scientific change, each year now brings disruptions that once defined generations. Universities, like our other organizational structures, are now challenged to adapt and respond, while preserving their core values.

## Telling the Future the Past

As **Figure 1** suggests, the history of U.S. higher education is one of punctuated equilibrium. The current structure of the American research university originated in the postbellum 1940s and 1950s. That is, it is a quite recent invention, with structures and programs created and funded in large part for economic benefit and national security. **The Colonial Era.** The nine “colonial colleges” were founded before the U.S. Revolutionary War and included all of the current Ivy League schools (except Cornell) plus Rutgers (then Queen's College) and William





**Figure 1** An abbreviated history of U.S. universities

and Mary. Harvard, the oldest, was founded in 1636 and was later named after clergyman John Harvard when he bequeathed his library and half of his estate to the college.

Many of these institutions were created to provide instruction to future clergy of various denominations. As Harvard noted in a 1643 brochure, the college's purpose was "To advance Learning and perpetuate it to Posterity; dreading to leave an illiterate Ministry to the Churches." Curricula were derived from the classic English model, itself an evolutionary variant of the medieval *trivium* (grammar, logic and rhetoric) and *quadrivium* (arithmetic, geometry, astronomy and music) with Latin and Greek fluency.

Following these early universities, and reflecting the growth and dispersion of the U.S. population, additional universities were created after the U.S. Revolutionary War, including the University of Virginia (founded by Thomas Jefferson) and the North Carolina at Chapel Hill. Jefferson argued that an educated popu-

lace was necessary for the successful perpetuation of democracy, noting, "Whenever the people are well-informed, they can be trusted with their own government." Despite these secular extensions, the notion of education for practical pursuits was a decidedly secondary, often irrelevant consideration. This remained the status quo until the U.S. Civil War and the first major expansion of the Federal role in university life.

**Land Grants and the Morrill Act.** In 1862, Vermont Representative Justin Smith Morrill introduced a bill to grant each state 30,000 acres of public land for each Senator and Representative (based on the 1860 census). Proceeds from the land sales were to be invested in an endowment to support colleges of agriculture and mechanical arts in each of the states. In response, 37 states developed land-grant universities between 1862 and 1870. For the first time, practical training became a major focus of U.S. higher education. The land-grant concept was further expanded by the Smith-Lever Act of

1914, which created the agricultural cooperative extension service.

Throughout the late nineteenth and early twentieth centuries, Congressional intent to provide economically useful information to the citizens of a largely agrarian society via on-site university and engagement programs was pointed and clear. The result was a striking transformation in agricultural practice among small farmers, and a personal awareness of university engagement. The land-grant institutions evolved from their early practice to encompass a broad-based educational mission that encouraged both the life of the mind and practical skills.

**Vannevar Bush and World War II Science.** World War II saw the dramatic rise of university-led engineering and science as technological enablers of defense capabilities. In his seminal July 1945 memorandum, *Science, The Endless Frontier*, Vannevar Bush argued cogently and persuasively that Federal investment in science was crucial, noting that “... without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world.”

Bush had originally argued for a single science, integrated agency that included basic, defense, and medical research. After a tortuous political debate, the National Science Foundation (NSF) was created in 1950 to “*promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense.*” Today, NSF is but one of a portfolio of funding agencies that includes both basic research and so-called mission agencies, including the

National Institutes of Health, the Department of Energy, and the Department of Defense.

**The G.I. Bill.** The Servicemen’s Readjustment Act of 1944 – commonly known as the GI Bill of Rights – further transformed American higher education. It provided for college or vocational education for returning World War II veterans, a year of unemployment insurance and authorized loans for business starts and housing purchases. The economic and social effects of the G.I. Bill were profound.

Millions of degree seekers appeared on college campuses, forcing a dramatic and unprecedented expansion of college facilities and infrastructure. Enrollments often doubled in only a year or two. The influx of students also transformed college culture and expectations; a battle-hardened veteran had rather different educational expectations than a naïve 18-year-old scion of privilege. Over two million veterans received college educations in the war’s aftermath, and the number of U.S. college degrees awarded doubled between 1940 and 1950.

**Sputnik and the NDEA.** In response to the Soviet Union’s 1957 launch of Sputnik I, the U.S. passed the 1958 National Defense Education Act (NDEA). The NDEA was intended to increase the number of trained scientists and engineers able to compete with the Soviet Union. As such, it included support for college loans, greater investment in science, mathematics, and foreign language instruction in primary and secondary schools, funding for graduate fellowships and vocational-technical training. In its

own way, the NDEA was as transformative as the G.I. Bill, elevating Federal support for education generally and scientific education in particular as a national competitive priority during the Cold War. It changed the formula for Federal funding of university education and advanced science and engineering research within universities, rather than in separate institutes.

The astonishing intellectual and economic output from state and federal investment in higher education is perhaps unrivaled in history, and it has made the U.S. a magnet for the best and brightest minds on the planet. Against that backdrop, we now see declining state support and rising tuition costs, with selective student disenfranchisement. Concurrently, constrained research budgets have shattered the decades-old expectation that our best and brightest scholars and researchers would have the freedom and financial support to explore and discover.

### ***Quo Vadis: The Global Era***

What is the balance between intellectual inquiry and practical engagement? What is engaged scholarship? What are the “mechanical and industrial arts” for the 21<sup>st</sup> century? What are verities, the intellectual and operational truths that now dance as shadows in Plato’s Cave? What is the 21<sup>st</sup> century public research university?

Any societal compact reification begins with identifying the irreducible core – the essential values that define academia. Quite clearly, these are unfettered discovery (original scholarship and research), transference (student education

and training) and fulfillment (societal engagement and services). In each domain, the modern *trivium* explores the human condition, matter and the universe, and life and nature. Put another way, public research universities create new knowledge, transfer insights and ideas, and deliver solutions to societal problems

The American research university has changed radically and repeatedly over the past century. It emerged from the Cold War as a federally funded instrument of social change, economic competitiveness, and national security. There is no reason, indeed ample precedent to the contrary, to believe that it will not continue to evolve rapidly and radically. In this spirit, I humbly posit the following principles to guide our future, illustrated in **Figure 2**.

**Accelerating Change.** The pace of societal, technological, and economic change continues to accelerate. Universities must be equally nimble, recognizing that we are the citizen’s instrument and must demonstrate our differential value to our constituents.

**Knowledge and Skills Enhancement.** A corollary of accelerating change is a shift in the episodic nature of university education. No longer will the knowledge and skills acquired at age 20 last a lifetime. They must be refreshed continually. University educational delivery must adapt accordingly, in recognition that a mid-career worker wants new knowledge and skills, not necessarily a degree.

**Universal Franchise.** In a knowledge world, advantage accrues to those regions that most effectively and efficiently attract, educate, and empower



**Figure 2** University futures and organizational change

knowledge workers, without regard to ethnicity, national origin, socioeconomic status, sexual orientation, gender, religious beliefs, or politics. Talented people have always been and forever will be in short supply, but all of our citizens must be mobilized, not just the wealthiest or the most privileged.

the biggest challenges of the 21<sup>st</sup> century requires catholic, multidisciplinary teams – scholars, government leaders, and industry experts – who can share ideas, skills, and insights, without disciplinary silos.

**Societal Engagement.** The key lesson from university history is repeated

**Organizational Nimbleness.** As needs and opportunities shift, marshalling resources to adapt and respond, depends on flexibility and willingness to adjust organizational structures.

**Disciplinary Fusion.** Complex problems are rarely amenable to simplistic, isolated solutions, yet university structures reward individual excellence and depth and often punish collaborative exploration and breadth. Addressing



**Figure 3** University of Iowa Mobile Museum

rebalancing of values – scholarship and knowledge acquisition as intrinsic goods and their application to practical problems and individual needs. Witness the transformative effects of the Morrill Act, the G.I. Bill, the NDEA and the Civil Rights Act. We must protect our core values while also engaging society to address pressing problems.

**Global Perspective.** We are each citizens of the world, affected by and affecting our global partners, despite our U.S. tendencies for isolationism. We must educate our students and our citizens for global citizenship, and give them an understanding of diverse cultures, languages, and processes.

#### **The Iowa Experience**

Reflecting shifting societal expectations, the University of Iowa has launched several initiatives to assist its faculty, staff and students in scholarship and research, technology transfer, economic development, and societal engagement. The following examples are just a few of these broad ranging initiatives.

**Outreach and Mobile Museum.** The University of Iowa Mobile Museum<sup>1</sup> is a partnership among the University's Museum of Natural History and Old Capitol Museum, the Office of the State Archeologist, and the Office of the Vice-President for Research and Economic Development. Designed to allow annual replacement and refresh of its contents, the mobile museum includes displays on university research and scholarship as well as Iowa history, both natural and cultural. The 38-foot long RV, custom built

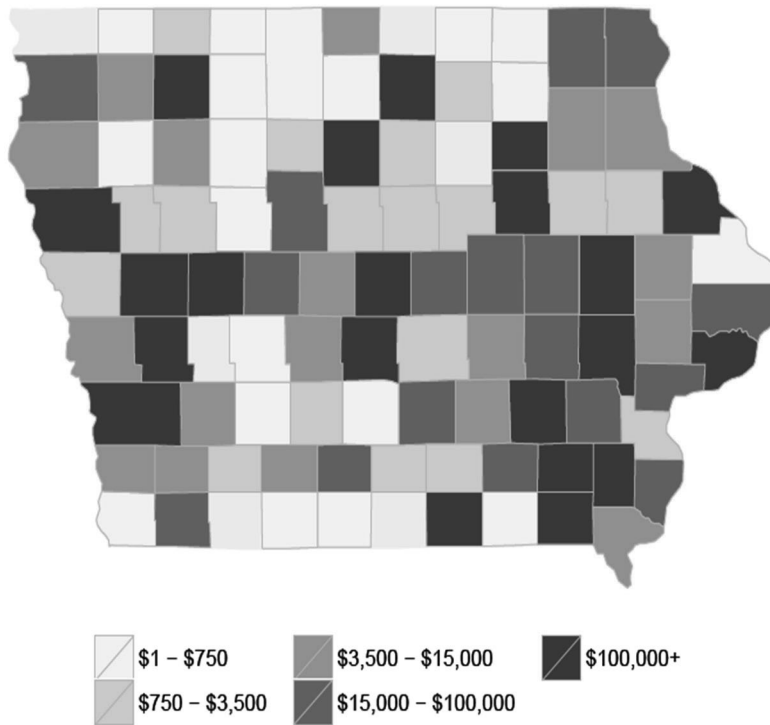
by Winnebago Industries and shown in Figure 3, travels across Iowa, visiting schools, libraries, community events, and the state fair. This statewide outreach exposes K-12 students and Iowans to research breakthroughs and the university experience.

**Research Metrics.** Working with other members of the Committee on Institutional Cooperation (CIC) – the Big Ten plus the University of Chicago – the University of Iowa is analyzing its research expenditures to identify their direct and indirect impact on the state economy. The UMETRICS project is a CIC-led initiative that builds on insights and ideas from the federal STARMETRICS initiative. By showing where research funds are spent, county by county, as well as the number of faculty, staff, and students employed by research grants and contracts, the UMETRICS data provides clear and compelling evidence of the economic impact of research funding. **Figure 4** illustrates county-by-county UMETRICS data.

**Ideation Summits and Salons.** Traditional academic scholarship and research reward deep specialization and expertise, an accelerating trend driven by the knowledge explosion and research funding competition. To encourage transdisciplinary scholarship and collaboration, the University of Iowa regularly invites hosts research summits that draw from the entire faculty. By facilitating discussion among scholars and researchers across the arts, humanities, social sci-

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<sup>1</sup> University of Iowa Mobile Museum, <http://discover.research.uiowa.edu/mobile-museum>



**Figure 4** University of Iowa UMETRICS Research Expenditures within Iowa

ences, engineering, medicine and business, our goal is to foster broad collaborations.

In addition to ideation events, the University also hosts salon events<sup>2</sup> to discuss challenging societal issues, drawing on the diverse perspectives and expertise of faculty. Example topics include the interplay of social norms, political power and biology on vaccinations and the spread of disease; evolving notions and expectations for privacy in the digital age; and political caucuses and communication in presidential elections.

<sup>2</sup> University of Iowa Salon Events, <http://research.uiowa.edu/impact/news/ideas-intersections-dinners-bring-together-scholars-researchers-and-artists>

**Internal Funding Initiatives.** The University of Iowa’s internal funding program<sup>3</sup> is structured to enable scholars and researchers to explore new directions, ones where they may not have the experience or data to be competitive for external funds. It also places high priority on rewarding high risk, multidisciplinary collaborations such as those that might emerge from ideation summits. In addition, these initiatives support acquisition of new instrumentation and facilities.

**Faculty Media Training.** The accelerating pace of scientific and technical discovery, with ever more

frequent public policy implications, together with rising scrutiny of publicly funded research, makes it essential that we in academia communicate our work, its importance, and its relevance, in accessible and easily understandable ways. To aid faculty in communication, the University hosts seminars on the art of presentation, targeting both research and public audiences.

We also host cohorts of faculty for intensive media training, working with professional journalists and journalism faculty. These daylong seminars include the

<sup>3</sup> University of Iowa Internal Funding Initiatives, <http://research.uiowa.edu/researchers/find-funding/internal-funding-initiatives-ifi>

capture and critique of brief video descriptions of research, discussion about how to interact with journalists, and techniques for effective communication with lay audiences. Faculty members leave the seminar with a video succinctly describing their research and its broader relevance.

**Faculty Fellows.** The Office of the Vice President for Research and Economic Development (OVPR&ED) hosts several faculty fellows. Each fellow spends approximately half of their time in the OVPR&ED for a period of two-three years, working on targeted projects and serving as ambassadors to the campus community. In addition to gaining administrative insight and experience, each fellow brings faculty perspectives and ideas that help shape research and economic development policy.

**Entrepreneurship and Economic Development.** The University of Iowa's economic development mission is central to its role as a public research university. The economic development enterprise<sup>4</sup> includes five interlocking elements:

- *UIPartners*, which works with small businesses across the state to help them remain competitive
- *UIVentures*, which assists faculty entrepreneurs with business planning and startup funding
- *UIProtolabs*, which helps companies and entrepreneurs across the state build prototypes of new projects, an essential step to demonstrating business viability
- *UIRF*, the University of Iowa Research Foundation, which licenses university inventions to both extant companies and entrepreneurial startups

- *UIRP*, the University of Iowa Research Park, which hosts startups and other businesses
- *JPEC*, the John Pappajohn Entrepreneurial Center, which trains students and faculty in business skills and Lean Launchpad business planning

Reaffirming the Dream

We face deep societal challenges – poverty, inequality, injustice, health and wellness, environmental sustainability, and economic uncertainty – and it is tempting to embrace a psychology of diminished expectations. However, we also have unprecedented opportunities, where the potential answers to age-old questions are tantalizingly close.

A great public research university is many things, derived from the three adjectives (great, public and research) and the noun (university):

- *A tabula rasa* for dreams
- A magnet for global talent
- A crucible of discovery and innovation
- An engine of the knowledge economy
- A framer of the crucial debates
- A transformative societal force

It is time to frame and engage the debate, to articulate our aspirations, and galvanize ourselves to collaborative action. Our future, and that of the country, depends on it.

*Quo vadis?* The future, of course.

#### Acknowledgments

My deep thanks to Susan Graham (UC Berkeley), Anita Jones (Virginia), Fred Schneider (Cornell) and others for insightful comments on early drafts of this essay.

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<sup>4</sup> University of Iowa Economic Development, <http://research.uiowa.edu/business>

## Shifting the Paradigm of Large-Scale Achievement Assessment or, Help! I'm Lost; Does Anyone Have a Map?

Neal Kingston, Professor, Dept. of Educational Psychology;  
Director, Achievement and Assessment Institute, University of Kansas

I had to get to the Lied Lodge in Nebraska City yesterday. But knowing where I was going was not enough.

I did not want to be like Daniel Boone, the famed frontiersman and explorer who when asked if he was ever lost said, "I can't say as ever I was lost, but I was bewildered once for three days" (Faragher, 1993, p. 65).

I actually knew a bit more than where I was going – I knew I was starting in Lawrence, Kansas. I knew even more than that. I knew I have to head west to Topeka then north to Nebraska City. But frankly that was not enough; I really needed a map. Or better yet, a GPS, because there could be detours or traffic jams.

I am an educational researcher – a psychometrician, not a geographical cartographer. Psychometricians apply statistical models to assessment responses and summarize those responses in a way that facilitates valid inferences about psychological and educational constructs underlying those assessments. In the field of psychometrics, the science of testing, at best we use road signs, or lists of standards that a child must master.

Road signs are not sufficient.

Unfortunately, there has been little direct connection between the subject matter we assess and statistical methods we have used to analyze test results and build test forms.

We have one set of methods for identifying the content we put on our tests and a completely unrelated set of methods for analyzing and producing results. Those results are shared on a numerical scale with no inherent meaning, such as 200 –



Figure 1. Section of Google Map showing geographical relationship between Lawrence, KS and Nebraska City, NE.



800, or 1 – 36, or 120 – 170, which are the score scales for the SATs, ACTs, and GREs respectively.

What does a student with a score of 340 on the SAT Mathematics test know? Do two students with the score of 27 on the ACT know the same things? And while the examples I gave are for admission tests that are not intended to provide feedback to improve student learning, the same thing is true about tests intended to provide such information, such as K-12 state tests or tests used to certify examinee knowledge.

Just like maps can help us navigate in the physical world, maps, could help us navigate the cognitive world.

The Dynamic Learning Maps Alternate Assessment was developed at the University of Kansas Achievement and Assessment Institute working closely with The Center for Literacy and Disability Studies at the University of North Carolina Chapel Hill Medical School.

Alternate Assessments are designed for students with significant cognitive

disabilities – the approximately 1% of students with the greatest intellectual challenges. These children are often invisible within their greater communities, being educated in separate classrooms and often in separate residential facilities. Most suffer from either intellectual disabilities, usually with IQs below 55, severe autism, or other conditions that interfere with their ability to process information. About ten percent of the alternate assessment population have no formal communication systems. There is high co-morbidity with single and multiple physical disabilities including motor control, deafness, and blindness.

The DLM was administered for the first time in spring 2015 to 15 of 18 states that have collaborated in building the assessment. We expect some additional states will use DLM next year.

There are a number of key principles underlying the development of the DLM Alternate Assessment, but today I will focus on the use of learning maps.

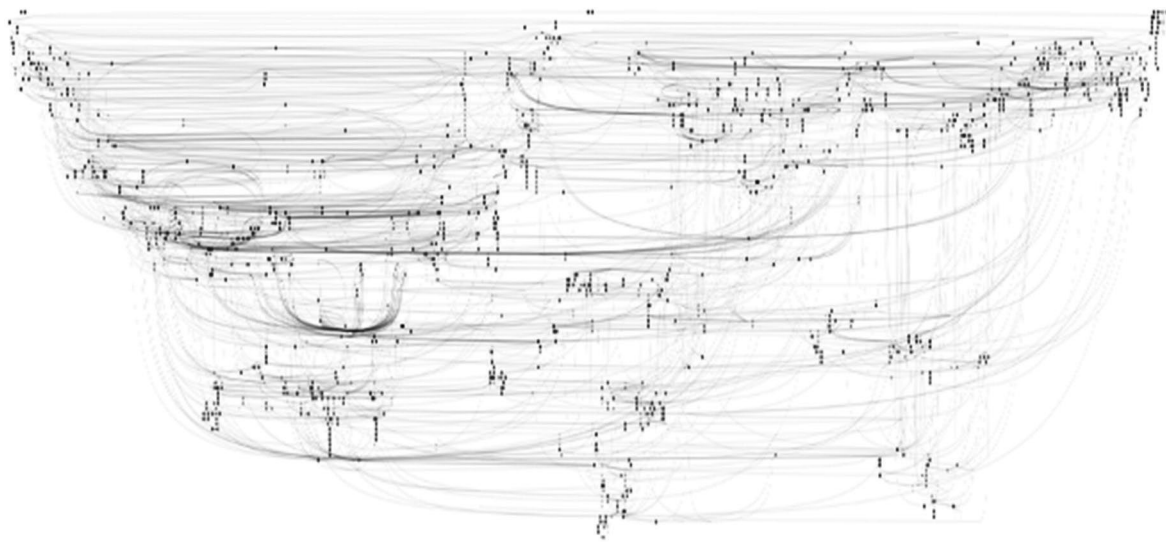


Figure 2. Mathematics learning map

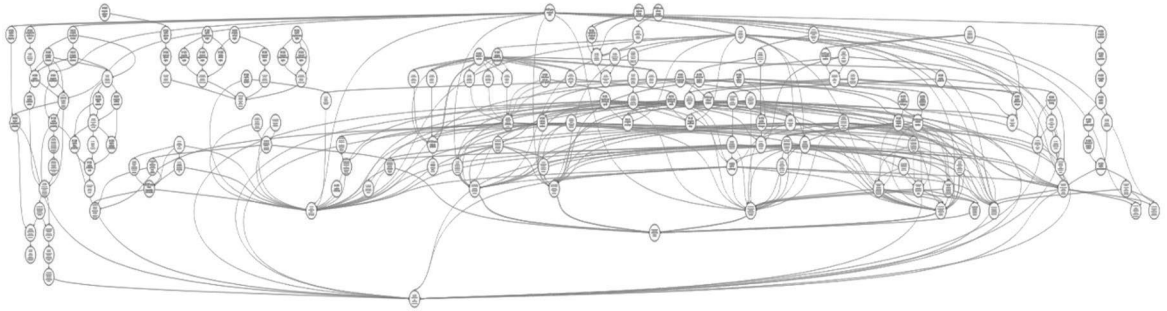


Figure 3. 7<sup>th</sup> Grade mathematics portion of the learning map

We had a team of about a dozen researchers spend more than two years scouring the research literature for studies showing what we know about how students learn academic content in English Language Arts and Mathematics. We had a handful of experts and hundreds of practicing educators review the maps. We identified a large number of nodes – knowledge, skills, and aspects of cognition: 159 that were foundational to both disciplines, 1,850 in English Language Arts and 2,554 in mathematics. We identified about 10,000 connections or pathways among the nodes. Figure 2 shows the current version of the mathematics learning map.

When looked at in its entirety the information in the maps is hidden. Even broken down it appeared overwhelming, as you can see from them section on constructing understandings of text.

Smaller areas, such as nodes related to the 173 nodes and 243 connections within grade 7 mathematics are much more manageable, but still too complicated to identify detail and facilitate teacher usage.

We were sure it would be off-putting to educators and we would have to hide it inside the code in our software. Luckily the educators who reviewed the map convinced us that we were wrong. In fact,

they wanted to take it home after our review session and start using it in their classrooms.

While we collected the maps and did not allow this at the time, we did create additional structures within the map to help all teachers with their understanding. Within each of English Language Arts and Mathematics, we identified nine conceptual areas, such as constructing understandings of text and calculating accurately and efficiently using simple arithmetic operations. A subset of the map nodes were identified as Essential Elements particularly important learning targets.

For each Essential Element we identified common learning pathways including nodes that supported mastering the targeted essential element. Here is an example related to the Essential Element, “Identify two related points the author makes in an informational text” – ELA EE.RI 3.8. On the left we see where in the map those nodes reside. On the right we have highlighted several important nodes.

Finally we pull out one or more nodes at each of five levels. In this case we have two initial precursor nodes “Notice what is new” and “Recognize same;” one distal precursor, “Determine similar or

different based on physical characteristics;" one proximal precursor, "Identify relationships between concrete facts or details;" the targeted essential element, "Identify two related points made by the author of an informational text;" and a successor skill, "Identify one or more reasons supporting a point in the text."

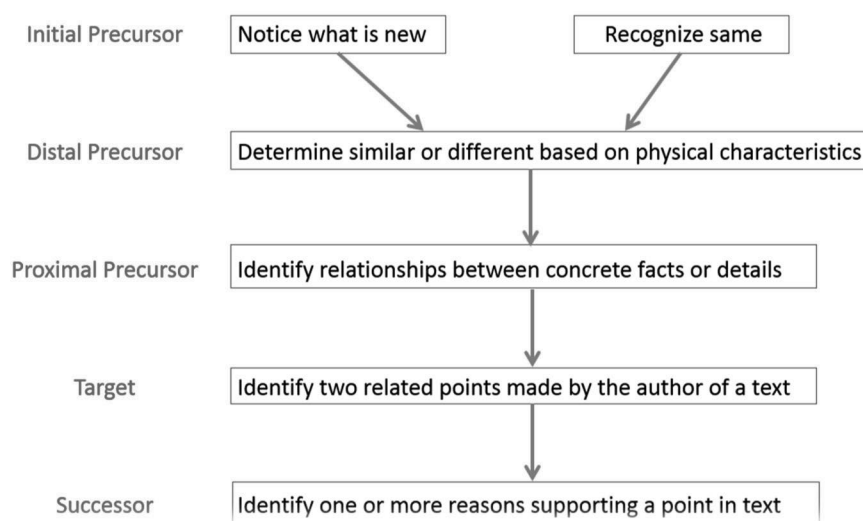
Now we have broken down the map to areas around each 538 English Language Arts and 172 Mathematics essential elements. Each of these mini-maps is relatively easy for a teacher to comprehend, and any individual teacher only needs to be able to use at most one hundred of the mini-maps to guide instruction.

With these maps our teachers are less likely to get lost! Once they decide where they are going and determine where they are starting they have information about the route they should take. And if the special needs of a particular child means that child needs to take a detour from the most common learning pathway, the map

shows the teacher how she or he can do that.

For more than a decade K-12 school assessments have been embedded in high-stakes accountability systems. This has led to an epidemic of teaching to tests not designed to be taught to. Moreover schools stop new instruction well in advance of annual testing and focus on test preparation.

The best test preparation should be good instruction. We must return to a paradigm of INSTRUCTION driving assessment, rather than the other way around. To this end, assessments must be developed based on the learning map as opposed to being based on a list of content specifications. To ensure this we created Essential Element Concept Maps to guide our test developers. These concept maps include the five level mini-maps, but also identify key vocabulary, and provide one or more templates for creating assessment tasks for the measured nodes.



**Figure 4.** Key nodes related to identifying two related points made by the author of a text.

After the tests are developed and administered we need to use statistical models consistent with our learning map. This means we cannot simply add up the number of items a student responded to correctly. We are not interested in a total score. Instead we are interested in which particular nodes a student mastered – a concept that relates directly to the map.

We need a different statistical approach such as Bayesian network analysis. Let me give you an example of how that would work.

Let's say I would like to know if it rained last night. Simple, you might say, just look out the window and see if your lawn is wet. But it is more complicated than that. There is a relationship among three potentially observable events:

- Did it rain last night?
- Was my sprinkler on?
- Is my grass wet?

Based on our prior knowledge we can add probabilities to these three events. In this case perhaps we know the probability of it raining in Lawrence on any random summer night. Let us say that probability is .2.

I must admit, my wife turns the sprinkler system on and off at our house. She also pays much better attention to weather forecasts than I do. If it is not going to rain she turns on the sprinkler 40% of the time – she does not want it on 100% of the time as that would be wasteful or even damage the lawn. However one percent of the time she forgets to turn it off when it is going to rain.

Finally I have a table of conditional probabilities of the grass being wet. If the sprinkler was off and it did not rain the probability of a wet lawn is 0 – there is no

morning dew in my neighborhood. If the sprinkler was not on but it rained there is an 80% chance the grass will be wet – the other 20% of the time it will have dried by morning. If the sprinkler came on but it did not rain, the probability of a wet lawn is .9 – the sprinkler comes on late enough so it is not likely it would be dry by the time I leave the house, even on a sunny warm morning. Finally, if the sprinkler was on AND it did rain the probability of a wet lawn is .99.

What I want to know is if my lawn is wet in the morning, what is the probability that it rained?

Sir Thomas Bayes, an English Presbyterian minister and statistician who lived in the early 1700s comes to our rescue. Though he never published his notes, a remarkable theorem he invented was discovered after his death. That theorem is as follows.

We want to know the probability it rained given the lawn is wet, but what we

$$P(A|B) = \frac{P(B|A) P(A)}{P(B)}$$

have is the probability the lawn is wet given it rained. Bayes theorem lets us calculate the desired probability, which is .36.

$$P(R = T|G = T) = \frac{.016038}{.44838} = .3577$$

The same logic applies when we are trying to estimate the probability a student has mastered a node in the learning map given we know which of the three test items the student answered correctly. This is significantly more difficult than in the rain example, both because we cannot

directly observe node mastery and because we have such a large number of nodes for which probabilities must be estimated.

Luckily, there is a family of statistical estimation methods we can use to estimate mastery probabilities for large numbers of observable and non-observable nodes. It is called Markov Chain Monte Carlo estimation, often abbreviated MCMC. We can do that with multiple

In addition, reports based on learning maps could be dynamic and show us student progress over time.

Finally, although we started our learning map with the goal of improving instruction and assessment for students with significant cognitive disabilities, there is no reason this approach would not work equally as well for all students.

We have had one follow up grant to expand the map in mathematics to make

Essential Element		Level Mastery				
		1	2	3	4 (Target)	5
Area	RL.3.1	Attend to object characteristics	Identify familiar people, objects, places, and events	Answer who and what questions and identify details in a familiar story	Answer who and what questions about story details	Answer who, what, when, and where questions about story details
	RL.3.2	Seek absent objects	Identify familiar people, objects, places, and events	Associate details with events in a familiar story	Associate details with events in diverse stories	Recount diverse stories with key details
	RL.3.3	Identify feeling states in self	Identify feeling words	Identify the feelings of characters in familiar stories	Identify the feelings of characters in a story	Identify character feelings and relate to actions
	RL.3.5	Express interest in book sharing	Differentiate between text and pictures	Identify details and beginning and end of a familiar story	Determine the beginning, middle, and end of a familiar story with a logical order	Identify beginning and end of a story

Figure 5. Section of prototype score report where shading indicates level of mastery attained

nodes each with multiple connected items.

Once we have estimated mastery of nodes we can provide reports that, based on focus groups we have had with parents and educators, provide information that is concrete, understandable, and actionable. No more trying to figure out what it means for your child to have a score of 27.

These reports can even suggest what next area of study would best serve as a next instructional focus – either for the class as a whole or for any individual student. That is, the use of learning maps makes it much easier for teachers to personalize instruction.

it cover the K-12 content necessary for all students and to provide better map visualization tools. We have just applied for another grant that would complete the build out of the map in English Language Arts and expand the mapping software capabilities to allow the tagging of instructional resources, professional development materials, and formative assessments to the nodes (or groups of nodes) in the map. This could allow commercial entities to license the map and software to deliver their own content. A third recent NSF grant application would allow us to map out the components of the data sciences at KU. Also, a medical certification

organization has expressed interest in using this approach in the determination of clinical judgment skills.

Maps organize information in ways familiar to most people. The map metaphor is powerful. The possibilities of this approach cross disciplines.

Of important note in these times of diminishing federal research support in the social sciences, this line of research has been supported by a federal agency (U.S. Department of Education), a large

foundation (Bill and Melinda Gates Foundation) and a consortium consisting of 18 state departments of education. This latter source of funding appears to be under-recognized and underutilized by research universities.

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# The Trouble (and Opportunities) With Ed Schools in the Research University

Christopher Morpew, Executive Associate Dean for Research and Innovation; Professor, College of Education, University of Iowa

## Bemoaning and Diagnosing Ed Schools

David Labaree, writing in 1996 in his influential essay *The trouble with Ed Schools* (which he later expanded into a book of the same name) diagnoses the problems that Schools or Colleges of Education have faced, both historically and currently. Ed Schools, he points out, have seemingly always been a punching bag for the average citizen and state legislator, who likes their local public school and teachers, but have no respect for the state of public education in general, nor the institutions that produce teachers. Ed Schools, he writes, have responded to coercive market and government pressures only to discover that, in doing so, they put themselves in the unenviable but necessary position of catering to stigmatized populations that results in indictment by association. Ed Schools have played into the perception that they take in low quality students, and produce low quality graduates who don't benefit from the social mobility a college degree in the same way as do the graduates of engineering and business schools.

At the time Labaree was writing, an influential group of Ed School leaders (including deans) had penned several essays bemoaning and excoriating Ed Schools for their failure to modernize, establish connections with public schools, and push for education reform. This was the last straw; even Ed Schools' leaders had piled on to the bandwagon. Yet, Labaree's essay isn't all doom and gloom. After explaining why Ed Schools – rightfully in many cases – deserve their reputation, Labaree points out several features of Ed Schools that present an opportunity in the current political and social environment. These features include a degree with a job opportunity formally attached, a head start on conducting practical research about an institution that everyone cares about, and a history of delivering education

at a lower cost than many other parts of the university.

I find Labaree's work particularly illuminating and will use his short essay as a springboard to discuss what I see as the challenges and opportunities for Ed Schools in Research Extensive Universities, like those that bring together scholars and administrators to the Merrill Advanced Studies Retreat each year. In the process, I will explain why I think Ed Schools – for all of their real problems – may be positioned quite strategically in the modern research university.

### *The Trouble with (Research in) Ed Schools*

Unlike some other parts of the university that seem well-suited for producing high quality scholarship, the Ed School is organized in a way that, to some

extent, gets in the way of doing research. Unlike degree programs in history or physics, teacher preparation and administrator licensure programs are subject to the accreditation whims of state legislators and entities like boards of educational examiners who make greater and greater demands -- some justified, others not so much -- of undergraduate and graduate degree programs linked to certification. These demands include specific coursework with defined objectives, clinical hours spent in the K-12 building or classroom, and requirements that instructors have experience as teachers, principals, or superintendents.

These certification requirements present real constraints to the research capacity of Ed Schools. First, they reduce the ability of Ed School professors to construct a curriculum that prepares students to be teachers and administrators and simultaneously take advantage of the research university infrastructure. The pressure to meet state requirements in a timely manner gets in the way of opportunities that students in history and physics might have to engage in time-consuming research projects with faculty or pursue a second (or third) major. This is true, as well, of the graduate students in programs tied to certification, many of whom might be interested in working directly with faculty on research projects, but cannot step away from their teaching or administrative positions to pursue a degree full-time because doing so would put them at a competitive disadvantage on the job market once they graduate.

Second, the clinical expectations present real challenges for the students and professors in Ed Schools. High quality

clinical experiences must be worked out with partner schools, supervised, and evaluated frequently and this requires resources -- including faculty time -- that otherwise might be used for the research. Research universities don't hire scholars to supervise students' clinical experiences, but Ed Schools must find ways to engage faculty in these clinical experiences and that can be difficult. Finally, the typical requirement that certification programs be staffed with instructors who have practical experience as principals or superintendents greatly restricts the labor pool from which Ed Schools might hire their faculty. It is significantly more difficult to identify and hire a promising junior scholar who has experience as a high school principal than to hire a new Ph.D. with an ambitious research agenda who has never worked in a school.

An additional problem consistent with both Labaree's diagnosis and problematic for research productivity in Ed Schools is the fact that Ed Schools tend to hire experts in education rather than experts in specific disciplines. That is, the typical professor in an Ed School is a graduate of, for example, an educational psychology program, not a psychology program. Likewise, the historians and sociologists of education were more than likely trained in other Ed Schools, rather than in history or sociology Ph.D. programs. This isn't to say that these scholars can't function as high quality psychologists or historians. They can and do. But there are disadvantages -- when pursuing grants or engaging with professional associations linked to disciplines -- that accompany being trained in Ed Schools rather than in Colleges of Liberal Arts and



Sciences. These disadvantages include being overlooked by foundations and/or review panels at federal funding agencies that are quick to cede the high ground (and funding dollars) to economists or other scholars who have PhDs in academic disciplines.

### *Research Opportunities In Ed Schools*

Labaree ends his essay on an optimistic note, extolling the opportunities available to Ed School as a result of their connections with schools and their unique histories. I share his sentiment relative to Ed Schools' research opportunities.

First and foremost, Ed Schools benefit from a multidisciplinary approach to research. This advantage is the result of the same handicap that I identify above: the likelihood that Ed School scholars are trained in other Ed Schools, rather than in disciplines in the arts and sciences. Ed School professors are trained to think about education-related problems first and foremost. While they are trained as sociologists or counselors, their Ed School training allows them to consider questions from a perspective that incorporates at least one discipline and fundamental knowledge about schools as institutions. Ed School professors, precisely because they are not trained in a single discipline, tend not to be trapped in the same methodologies and conceptual frameworks that might dominate a discipline. A focus on schools and the problems that affect them also contributes to Ed Scholars' willingness to embrace collaborative research projects.

The recent growth in interest in schools and public education by large

foundations like Gates is a second potential advantage for Ed Schools. Not only has Gates' interest in schools and school reform opened up funding opportunities for research on public education, it has also shone a spotlight on education research. Gates' coattails are long and its interest has spurred other large and small foundations to focus their sights on schools and educational reform as well. Ed School researchers are in a good position to secure funding and highlight their expertise. Potential rivals are many; particularly scholars from disciplines like economics who have convinced many funders that their methods and approaches are more suitable than Ed Schools' researchers for diagnosing the trouble with schools. Ultimately, though, much of the best work on schools will be done by Ed Scholars because of their intimate and unique knowledge of how schools are organized and function.

Finally, Ed Schools have an intra-institutional advantage that Labaree acknowledges and that I believe should be exploited by more strategic university leaders. Ed Schools are relatively inexpensive. This advantage is manifested in several ways. Faculty salaries are one part of the algebra. Ed School researchers make less than their peers in the health sciences, business, and often less than faculty in natural and physical sciences. Start-up costs are less as well. While engineering faculty and those in the health sciences may require start-up packages approaching or exceeding hundreds of thousands of dollars, a generous start-up package for a junior faculty member in an Ed School might be one-fifth that size or

less. The start-up costs mirror the research costs of Ed School scholars. Generally, expensive labs are not required (though some Ed School researchers who study child development or use sophisticated methods that require expensive computer hardware and software may require access to physical labs). These cost advantages matter now and may matter more in the future. As provosts struggle with the cost of the arms race in the sciences, some may (and should) come to the conclusion that competing for smaller grants that incur smaller costs may be part of a winning strategy to build research capacity and pockets of excellence on campus.

Ultimately, the trouble with Ed Schools is both real and a product of perception. The real part is a function of what Labaree describes as Ed Schools' longstanding links to historically marginalized populations and soft, applied problems. That is not likely to change. The perception part is something that Ed School and University leaders can do something about.

## Social and Behavioral Sciences Research: is now the time to invest?

**Steve Goddard, Associate Vice Chancellor for Research,  
University of Nebraska-Lincoln**

**Dan Hoyt, Director, Social and Behavioral Sciences Research Consortium,  
University of Nebraska**

Social and behavioral sciences are broad, interrelated fields of study. The core social sciences consist of anthropology, economics, geography, sociology, and political science. Researchers in the social sciences often use methods similar to the natural sciences as tools for understanding human behavior in societal contexts. The behavioral sciences consist of education, psychology, social neuroscience, communication and cognitive science, and researchers in these fields often use empirical data to investigate the decision processes and communication strategies. Within the structure of universities we also find social and behavioral scientists located across a broad range of academic units including agricultural economics, demography, educational psychology, health and nutrition, and public health. Researchers in both groups frequently engage a combination of basic and applied research, with the applied research typically involving interventions designed to improve health and related outcomes.

The National Science Foundation (NSF) and the National Institutes of Health (NIH) fund the majority of social and behavioral sciences research (SBSR) in the U.S., though agencies such as the Department of Education (DoE), the Department of Defense (DoD), the Department of Agriculture (USDA), the Center for Disease Control and Prevention (CDC), the National Institute of Justice (NIJ) and the Administration for Children and Families. The Agency for Healthcare Research and Quality (AHRQ) are also well known supporters of SBSR. Nationally, SBSR receives \$921M in federal funding. While significant, this amount pales in comparison to the \$40.1B of federal funding for all science and engineering. Typical SBSR

grants range in value from \$10K to \$7M. The following list of selected active University of Nebraska-Lincoln (UNL) grants illustrates this range:

- Doctoral Dissertation improvement grant (NSF): \$11,997
- Alcohol, Trauma and Intrusions (NIH): \$128,916
- Intelligent Support to Deterrence Operations (DoD): \$99,811
- Redesigning Science Surveys (USDA): \$115,000
- Ecological Model of Latino Youth (NSF): \$339,935
- Randomized Trial in Rural Education (DoE): \$2,999,994
- Native American Substance Abuse Prevention (NIH): \$3,762,799

State	Total SBSR Funding	Funding by Agency	Top Universities
Iowa	\$ 21.2 Million	NIH \$ 11.6 Million NSF \$ 1.6 Million Other \$ 7.6 Million	U. of Iowa \$ 11.1 M Iowa State \$ 9.2 M
Kansas	\$ 31.5 Million	NIH \$ 11.6 Million NSF \$ 3.7 Million Other \$ 22.5 Million	U. of Kansas \$ 22.3 M Kansas State \$ 5.5 M WSU \$ 3.7 M
Missouri	\$ 20.0 Million	NIH \$ 9.2 Million NSF \$ 3.7 Million Other \$ 6.6 Million	U. of Missouri \$ 8.9 M Washington U. \$ 5.4 M UM St. Louis \$ 3.3 M
Nebraska	\$ 16.8 Million	NIH \$ 5.1 Million NSF \$ 2.2 Million Other \$ 8.5 Million	UNL \$ 15.8 M

Table 1: SBSR funding by state, agency, and top universities in the region.

Table 1 provides a breakdown of federally supported SBSR by State in Iowa, Kansas, Missouri, and Nebraska (Consortium of Social Science Associations, State Fact Sheets, n.d.). As shown in Table 1, each of the major universities in these four states have well-funded SBSR programs, with diverse funding portfolios.

This is important because funding for traditional disciplinary SBSR is becoming increasingly more competitive due to an increasing pool of applicants and decreases in SBSR federal funding. The result, as we see across the funding landscape, is lower federal funding rates.

While it is true that overall research funding has declined in real dollars over

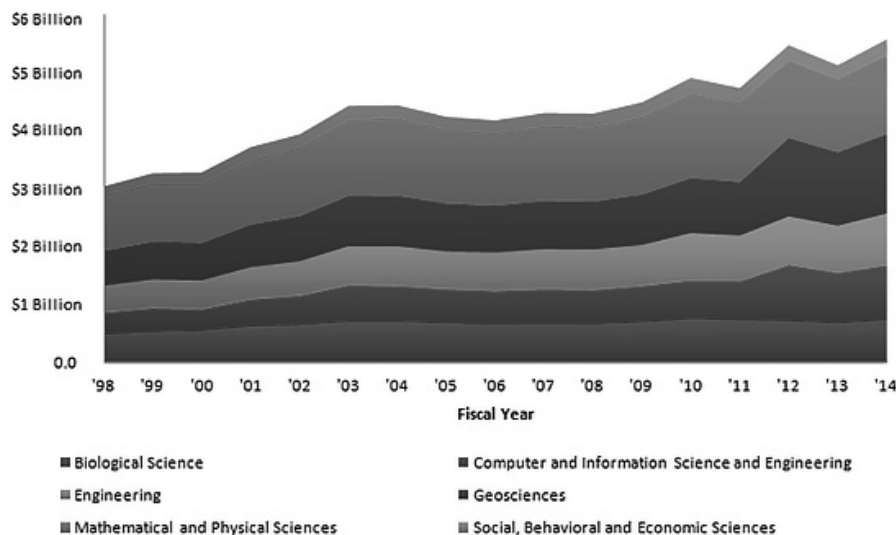


Table 2: NSF funding by directorate from FY 1998 through FY 2014

the past decade, SBSR has been particularly hard hit. Consider for example the NSF research funding trends from 1998 through 2014, as shown in Table 2. NSF research funding (excluding educational, equipment, and operations) has increased from approximately \$3.5B in FY 1998 to approximately \$6.1B in FY 2014 (Todd, 2014). However, the research funding allocated to SBSR has remained a small proportion of the overall NSF research budget, declining from 4.9% in 1998 to 4.4% in 2014.

Changes in federal funding from FY

ample, the House Commerce, Justice, Science and Related Agencies (CJS) Appropriations Subcommittee FY16 report (2015) includes the following problematic language impacting social science funding:

“The Committee directs NSF to ensure that Mathematical and Physical Sciences; Computer and Information Sciences and Engineering; Engineering; and Biological Sciences comprise no less than 70 percent of the funding within Research and Related Activities.”

Agency	2014 \$ Millions	2015 \$ Millions	Percent Change
NIH	29,934	30,084	+ .5
NSF	7,171	7,344	+ 2.4
CDC	5,807	5,968	+ 2.8
DoE (IES)	577	574	- .5
ARHQ	371	363	- 2.0
DoJ (BJS & NIJ)	85	77	- 9.5

Table 3: Funding by agency for FY 2014 and FY 2015, with percent change noted.

2014 to FY 2015, shown in Table 3, have hit SBSR particularly hard. For example, DoE, ARHQ, and the Department of Justice (DoJ) are strong supporters of SBSR, and each experienced a budget cut. Funding directives for NIH and NSF include language for specific funding priorities that impact SBSR funding.

Fiscal Year 2016 looks to be even worse. At the time of this writing, Congress has not yet approved a FY16 budget (or even a Continuing Resolution), but early indicators indicate Congress is taking aim at SBSR funding in FY16. For ex-

In general, agencies and programs that support SBSR would fare quite poorly in the bill. Among the many challenging provisions, the bill seeks to (i) limit support for social science research at NSF, (ii) enable potentially deep cuts to the National Institute of Justice and Bureau of Justice Statistics, and (iii) degrade the American Community Survey within the Census Bureau (Consortium of Social Science Associations, 2015).

The House report states:

“Social, Behavioral and Economic (SBE) Sciences—Long-standing congressional concerns persist about the merit

of activities funded through NSF’s SBE Directorate. In order to address these concerns, NSF must ensure that SBE awards are consistent with NSF’s scientific quality standards and aligned to national interests. The Committee recognizes the intrinsic value in SBE sciences and the direct responsiveness of SBE activities to Committee priorities, including studies on the effects of youth exposure to media violence and the collection of data for STEM education indicators.”

Table 4 provides a summary of the U.S. House and Senate versions of FY 2016 funding bills. Potential impacts on SBSR are not fully exposed by overall funding levels in NSF and NIH, but the

Institute of Educational Sciences (IES), within the DoE, is likely to experience a significant cut (up to 27%). If the House has its way, ARHQ will be completely eliminated with its budget being zeroed out.

At this point, one might wonder why any university would consider investing additional resources in SBSR. To answer this question, one must remember why we conduct SBSR and what we hope to gain. Our long-term success in addressing major economic, health, energy, environmental and national security challenges depends on understanding not only their technological and scientific complexities, but also the broader social, political and economic issues that serve

Agency	House	Senate
NIH	+\$100M	+\$2,000M (+\$2B)
NSF	Small increase	Slightly higher increase
CDC	Small increase	Small increase
DoE (IES)	-\$155M (-27%)	Small decrease
ARHQ	-\$363M (-100%)	-\$127M (-35%)
DoJ (BJS & NIJ)	Not Available	Not Available

Table 4: Proposed congressional changes in funding by agency for FY 2016.

impact becomes more visible when one starts to read the details of the bill. For example, House language on funding does not specify budgets for each directorate, but it includes language mandating the percentage of funding for certain classes of research, and specifies targeted initiatives, that would result in reductions in funding for the Social, Behavioral and Economic Sciences Directorate (SBE). The situation is much more dire for the smaller agencies that focus on SBSR. The

as the context for addressing these matters. For example, we all know we should eat balanced diets and exercise regularly, yet few of us do either. The answer to many of society’s problems are known, the challenge is figuring out how to change behaviors to adopt solutions to the problems ailing our society.

At UNL, we believe it is best to invest now, when the ‘market is down’, rather than wait until the ‘market is hot’. But we must make wise investments, so that we

are prepared for future funding opportunities and challenges. We need to move from thinking of research defined by disciplinary boundaries and expertise to research foci that require the collaboration of researchers across disciplines, bringing diverse theoretical and methodological approaches to address a common research challenge.

As societal problems have become more complex, it has become widely accepted that we need new ways to address today's research challenges. Thus, the past decade has been marked by a steady transition from funding traditional disciplinary-based research to increased funding of interdisciplinary research projects. Before addressing the impacts of that transition, it is important to define the term.

"Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice." (Committee on Facilitating Interdisciplinary Research, Committee on Science, Engineering, and Public Policy, 2004).

Aboelela et al. define interdisciplinary research as being

"based upon a conceptual model that links or integrates theoretical frameworks from those disciplines, uses study design and methodology that is not limited to any one field, and requires the use of perspectives and skills of the involved disciplines

throughout multiple phases of the research process." (Aboelela, Larson, Bakken, et al., 2007)

National funding agencies, such as NSF and NIH, have greatly increased the portions of their budgets allocated toward creating interdisciplinary research programs. For example, the NSF *Rebuilding the Mosaic* initiative promotes interdisciplinary, data intensive, and collaborative research with four crosscutting themes:

- Population Change: Fundamental to Unpacking Key Research Problems;
- Disparities: Sources and Consequences;
- Understanding: Brain, Behavior, Communication, Learning and Language; and
- Technology: New Media and Social Networks.

The Interdisciplinary Behavioral and Social Science Research (IBSS) competition promotes the conduct of interdisciplinary research by teams of investigators. Emphasis is placed on support for research that involves researchers from multiple SBE disciplinary fields and that integrates scientific theoretical approaches and methodologies from multiple SBE disciplinary fields.

Importantly, interdisciplinary funding opportunities are not limited to SBSR directorates.

- Secure and Trustworthy Cyberspace (SaTC): The National Science and Technology Council (NSTC) with the cooperation of NSF issued a broad, coordinated Federal strategic plan for cybersecurity research that "requires a dedicated approach to research, development, and education that leverages the disciplines of mathematics

- and statistics, *the social sciences*, and engineering together with the computing, communications and information sciences". (NSF Program Solicitation NSF 15-575, 2015).
- Critical Techniques and Technologies for Advancing Foundations and Applications of Big Data Science and Engineering (BIGDATA): "The *BIGDATA* program seeks novel approaches in computer science, statistics, computational science, and mathematics, along with innovative applications in domain science, *including social and behavioral sciences*, geosciences, education, biology, the physical sciences, and engineering that lead towards the further development of the interdisciplinary field of data science." (NSF Program Solicitation 15-544, 2015).
  - The NIH has taken a bolder approach to interdisciplinary research (IR):
 

"Health research traditionally has been organized much like a series of cottage industries, lumping researchers into specialty areas, where their efforts remain disconnected from the greater whole by artificial barriers constructed by technical and language differences between different disciplines and departmentally-based specialties. But, as science has advanced over the past decade, two fundamental themes are apparent: the study of human biology and behavior is a wonderfully dynamic process, and the traditional divisions within health research may in some instances impede the pace of scientific discovery."

    - "The broad goal for the IR program therefore, was to change academic research culture, both in the extramural research community and in the extramural program at the NIH, such that interdisciplinary approaches are facilitated. The Interdisciplinary Research Program included initiatives to dissolve academic department boundaries within academic institutions and increase cooperation between institutions, train scientists to cultivate interdisciplinary efforts, and build bridges between the biological sciences and the behavioral and social sciences. Collectively, these efforts were intended to change academic research culture so that interdisciplinary approaches and team science are a normal mode of conducting research and scientists who pursue these approaches are adequately recognized and rewarded." (NIH Office of Strategic Coordination — The Common Fund, n.d.).
    - The NIH Office of Behavioral and Social Sciences Research seeks to address the "complexity inherent in behavioral and social phenomena, referred to as systems science methodologies" and "promote interdisciplinary *collaboration among health researchers and experts in computational approaches* to further the development of modeling- and simulation-based systems science methodologies and their application." (NIH Funding Opportunity Announcement PAR-15-047, 2014)

Similar language is found in their health disparities research programs:



“Research on the causes and solutions to health and disabilities disparities in the U. S. population. Health disparities between, on the one hand, racial/ethnic populations, lower socioeconomic classes, and rural residents and, on the other hand, the overall U.S. population are major public health concerns.” “Applications that utilize an *interdisciplinary approach, investigate multiple levels of analysis and/or employ innovative methods* such as systems science or community-based participatory research are particularly encouraged.” (NIH U.S. National Library of Medicine, n.d.)

Before the federal funding agencies started creating these ‘new’ programs, UNL was investing heavily in interdisciplinary SBSR. In 2004, the Nebraska Center for Research on Children, Youth, Families and Schools (CYFS) was established. The mission of the CYFS is “to advance the conduct of high-quality interdisciplinary research to promote the intellectual, behavioral, and social-emotional development and functioning of individuals across educational, familial and community contexts” (Nebraska Center for Research on Children, Youth, Families and Schools, n.d.). Investments in interdisciplinary SBSR faculty, centers, and other activities continues to this date, with the most recent high profile initiative being the Substance Abuse and Violence Initiative (SAVI), which began in 2010. SAVI brings together an interdisciplinary team to address the complex intersection between substance abuse and violence (Substance Abuse and Violence Initiative, n.d.).

In the Spring of 2012, UNL began to explore new methods, beyond interdisciplinary teams, to solving complex SBSR challenges by forming and funding transdisciplinary teams. Transdisciplinary Research is defined as “research efforts conducted by investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches to address a common problem” (Harvard Transdisciplinary Research in Energetics and Cancer Center, n.d.).

Based upon an assessment of where we had potential to expand collaborative research, our first step was to launch the Minority Health Disparities Initiative (MHDI) a transdisciplinary initiative with a focus on research, outreach, and training on health disparities (UNL Minority Health Disparities Initiative, n.d.). The investigators associated with this initiative have been successful in obtaining significant funding from NIH, with multiple \$3M+ R01 awards ranging from research on HIV Injection Risk Networks in Rural Puerto Rico to a Randomized Control Trial of a Culturally-Based Substance Abuse Intervention for Aboriginal Youth. MHDI also received funding from NSF for a summer REU program that aims to train the next generation of scientists in minority health disparities and social network analysis.

Shortly after that, UNL began the formation of the Center for Brain, Biology and Behavior (CB3). CB3 is a transdisciplinary center that brings together distinguished UNL faculty in the social, behav-

ioral and biological sciences and engineering (UNL Center for Brain, Biology and Behavior, n.d.). It also represents a unique partnership between academics and athletics at the UNL, with CB3 moving into a new expansion of Memorial Stadium in early 2014. This center's multidisciplinary environment enables diverse studies to expand our understanding of brain function and its effects on human behavior. An early and significant focus is on minor traumatic brain injury, which many athletes sustain in the form of concussions. More broadly, the center offices and labs house researchers who are at the forefront in the study of genetics, neuroscience, physiology, cognition and other areas of brain science.

The SBSR Initiative at UNL began in June of 2012 when the UNL Vice Chancellor for Research, Prem Paul, charged a faculty task force with answering several interrelated goals (UNL Social and Behavioral Sciences Research Initiative Task Force Report, 2014):

- enhance research excellence in the social and behavioral sciences at UNL,
- enhance competitiveness of UNL faculty in the social and behavioral sciences for extramural funding,
- identify gaps in faculty expertise that must be addressed to build successful teams of social and behavioral science researchers, and
- identify infrastructure or other needs to assist social and behavioral sciences faculty to be more productive and competitive for extramural funding.

A significant first accomplishment associated with the UNL SBSR Initiative

was to enhance infrastructure by winning a \$300,000 NSF grant to launch the Central Plains Research Data Center (RDC). The RDC is established in collaboration with the U.S. Census Bureau's Center for Economic Studies and includes partnership with the University of Nebraska Medical Center, Iowa State University, the University of Iowa and the University of South Dakota (UNL Central Plains Research Data Center, 2014). The center will be joining a network of 18 such centers in the U.S. that are jointly funded by the Census Bureau and the National Science Foundation. Slated to open in fall 2015, this Federal Statistical Research Data Center provides researchers in the social, behavioral, health and life sciences across the region a secure environment that allows access to restricted-use data from the Census Bureau, National Center for Health Statistics, Bureau of Labor Statistics, National Center for Education Statistics, Department of Transportation, Department of Housing and Urban Development and other federal sources. The center will provide access to a wealth of federal and regional data available on campus producing unique opportunities for enhancing social and behavioral research.

Building upon the recommendations outlined in the SBSR Initiative task force report, which was delivered in the spring of 2014, the UNL Office of Research and Economic Development established the Social and Behavioral Sciences Research Consortium (SBSRC) [UNL Social and Behavioral Sciences Research Consortium, n.d.]. The task force report highlighted areas of SBSR strength on cam-

pus, but noted the need to enhance connections and collaborations. This was a primary motivation in the branding of this effort as a “consortium”, highlighting a primary goal to bring social and behavioral scientists together to address common research challenges regardless of department, college, or even campus affiliation.

SBSRC’s mission is to facilitate the growth of social and behavioral research through coordinated activities that include:

- building a referral network for existing resources,
- enhancing research capacity,
- providing seed and voucher support,
- identifying and building research collaborations, and
- providing mentoring for new investigators.

An initial project in the center will be to use network science analyses to assess the type and extent of current interdisciplinary collaborations. The SBSRC is mapping all grant activity over the past 4 years that includes SBSR faculty. This analysis will be complemented by a second science network mapping of areas of research specialization and publications for the SBSR faculty. Combined, these analyses provide a baseline assessment of current interdisciplinary and transdisciplinary collaborations as well as identify opportunities for future collaborations. This work will also assist us in identifying areas where strategic faculty hires could greatly enhance our ability to build interdisciplinary teams positioned to respond to funding opportunities.

It was clear from the SBSR Initiative task force report that another need was to create a central assessment and referral mechanism. The report made it clear that more effort needed to be invested in informing faculty about existing SBSR resources. Again highlighting the ‘consortium’ element of the SBSRC, a core activity in the initial year is to create a comprehensive inventory of UNL SBSR resources and expertise. These data will then be used to build a referral network that will facilitate and support team research. SBSRC will identify new opportunities for collaboration, provide seed funding, coordinate external funding opportunities and provide mentoring for new faculty. In this effort, SBSRC will work closely with existing initiatives and centers, including seed funding in the form of vouchers for faculty to work with existing research support units.

The SBSR Initiative task force report also identified areas of research infrastructure that needed to be supported and/or enhanced to facilitate the growth of new social and behavioral collaborations. Accordingly, a first activity of the SBSRC was to submit a University of Nebraska Research Initiative grant for enhanced core facility support for social and behavioral research. This grant was funded at the start of the fiscal year and the SBSRC is in process of developing additional research infrastructure supporting social and behavioral research.

It is important to note that we have started this strategic investment with a strong base of social and behavioral scientists who were recruited to UNL through collaborative efforts of academic departments, colleges, and the office of

research. In addition, there are existing campus research centers with major social and behavioral research foci, including the Nebraska Center for Research on Children, Youth, Families and Schools, the Center for Children Families and the Law, and the Public Policy Center. The new investments in MHDI, CB3 and the RDC enhance this base of SBSR initiatives and centers. The referral, coordination, and supplemental services provided through SBSRC add the final element in the plan to increase SBSR funding in this competitive research environment.

In summary, is now the time to invest in social and behavioral science research? Obviously at UNL the answer is yes! We believe SBSR will continue to play significant roles in addressing our societies' biggest challenges. The growth opportunities, however, are in interdisciplinary and transdisciplinary team science approaches, rather than traditional single-investigator research projects. We are confident that our approach will position UNL to be a leading institution in transdisciplinary social and behavioral science research.

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**Wolfgang Kliemann**, Associate Vice President for Research

### Kansas State University

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### The University of Iowa

**Daniel Reed**, Vice President for Research and Economic Development

**Christopher Morphew**, Executive Associate Dean for Research and Innovation

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