

Building Research Infrastructure: Planning for Future Needs and Implementing for Change

*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 2016

Mabel L. Rice, Editor
Technical editor: Suzanne Scales

MASC Report No. 120
The University of Kansas

© 2016 The University of Kansas Merrill Advanced
Studies Center or individual author

In Memory of Prem Paul

I dedicate this collection of papers from the 20th annual Merrill Research Retreat to the memory of one of the participants, Prem Paul. Dr. Paul first attended the Retreat in 2002, as the Vice Chancellor for Research and Economic Development at the University of Nebraska, a position he assumed in July, 2001. In the subsequent years, he was a strong supporter of the Retreat, with an appreciation of the informativeness of the meetings and the opportunity to broaden his ever-expanding network of friends and potential colleagues. He always was excited about the content, his opportunity to share the innovations in research policy and activities at the University of Nebraska, and the opportunities to enhance regional collaborations and regional representation in national research policy developments. He brought to the meeting a lively intelligence, a great depth of knowledge in not only his own discipline of veterinary medicine but also across many content areas, great communication skills, and a real joy in representing the University of Nebraska. He inspired all of us in positive ways, as he pursued big ideas and a conviction that good scientists bring the promise of the future to all of us. We are grateful that he attended the meeting in 10 of the last 15 years, even as his health was failing. We are also grateful that he provided consistent support for the Retreat, with personal involvement in the selection of his designated UNL representatives in the years when he had other professional commitments at the time and could not attend.



On behalf of the participants over the last 15 years who had the opportunity to meet Prem and benefit from his intellectual and social strengths, I express our sense of loss and our condolences to Prem's family and many friends in the world of research activities, planning and advocacy. His legacy will be with us for a long time.

Mabel L. Rice, PhD
Fred & Virginia Merrill Distinguished Professor of Advanced Studies
University of Kansas
Director, Merrill Advanced Studies Center
January, 2017

TABLE OF CONTENTS

MASC Report No. 120

Introduction

Mabel L. Rice.....	v
Director, Merrill Advanced Studies Center, the University of Kansas	

Executive summary	vii
--------------------------------	-----

Keynote address

Kim A. Wilcox	1
Chancellor, University of California, Riverside	
<i>Clearing the Path on the Endless Frontier</i>	

Panel 1: Researchers

Alex W. Barker	10
University of Missouri	
<i>The Knowledge Archive as Convergence: Challenges of Scale and Sustainability for Scholarly Publishers, Libraries and Museums</i>	

Yo Jackson.....	21
University of Kansas	
<i>Child Trauma Research: Future Directions and Next Steps</i>	

Abiodun Akinwuntan	29
University of Kansas Medical Center	
<i>Technology and Research</i>	

Panel 2: Research Administrators

Jerry Zamzow	35
Iowa State University	
<i>Animal Research Support: The Transition from Ancillary Service to Contract Research Organization</i>	

April C. Mason.....	38
Kansas State University	
<i>The Value added of Education at a Public Research University</i>	

Sara Thomas Rosen	41
Georgia State University	
<i>Assessing Research Productivity</i>	

Panel 3: Researchers

Joseph A. Heppert..... 57

University of Kansas

Planning for Institutional Core Research Facilities in Uncertain Times

Sarah C. Larsen..... 67

University of Iowa

Enhancing University Research through Innovations in Graduate Education

Panel 4: Research Administrator

Brian L. Foster 75

University of Missouri

Infrastructure Planning and Implementation for Transformative and Incremental Research

Panel 5: Researcher and Administrator Panel

Carl W. Lejuez..... 87

University of Kansas

Seed Funding Programs in a Comprehensive Liberal Arts and Sciences College

Sally L. Maliski..... 96

University of Kansas Medical Center

Staying Strong and Healthy: Minimizing Cardiovascular and Metabolic Effects of Androgen Deprivation Therapy: A Study in Transition

Panel 6: Administrator Panel

Peter K. Dorhout..... 105

Kansas State University

Attracting and Retaining Competitive Faculty – Startups, Core Facilities, and Investment Strategies...Oh My!

LIST OF PARTICIPANTS and CREDENTIALS..... 113

Introduction

Mabel Rice

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

The following papers each address an aspect of the subject of the twentieth annual research policy retreat hosted by the Merrill Center: *Building Research Infrastructure: Planning for Future Needs and Implementing for Change*. 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 the focus was on new, and continuing, challenges in developing the human capital and physical infrastructure needed for front-line research in public universities.

Our keynote speaker for the event, Dr. Kim Wilcox, reminded us of the seminal contributions of Vannevar Bush to research policy, formulated as three core principles in the 1945 publication, *Science: The Endless Frontier*. Federal support of basic research continues to be guided by these principles. Dr. Wilcox suggests that progress is weakest for the third principle, "Access to higher education should be based on ability, not circumstance." He builds a case for the importance of doing better and offers as a model the success of UC Riverside in improving the outcomes of lowest-income and underrepresented minority students.

Benefactors Virginia and Fred Merrill make possible this series of retreats: The Research Mission of Public Universities. On behalf of the many participants over two decades, 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.

Twenty-one senior administrators and faculty from five institutions in Kansas, Missouri, Iowa and Nebraska attended in 2016, which marked our twentieth 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 collabora-

tion. 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. The 2015 retreat addressed the opportunities and challenges inherent in innovation and translational initiatives in the time of economic uncertainty that have an impact on goals to enhance research productivity.

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 2016 Merrill policy retreat on *Building Research Infrastructure: Planning for Future Needs and Implementing for Change*.

Executive summary

Clearing the Path on the Endless Frontier

Kim A. Wilcox, Chancellor, University of California, Riverside

- President Franklin Roosevelt tasked Dr. Vannevar Bush with creating a strategy for federal support of scientific research that built on the successes seen during wartime. With the help of scientists and scholars, Dr. Bush produced *Science: The Endless Frontier*, a document that managed to facilitate the world-changing scientific and technological developments over the last 70 years. Federal support of basic research continues to be guided by principles outlined by Bush. Among the recommendations, three core principles are essential to U.S. research.
- **The federal government should fund basic research through the nation’s universities.** Since 1953, the federal government has provided over 50% of the nation’s expenditures on basic research, with the majority of that funding going to universities. Recent declines present challenges for the nation’s research universities, including a reduction in research, and a narrow pipeline for early-career investigators, the future researchers.
- **Free inquiry is essential to the creation of new knowledge.** The freedom to pursue knowledge wherever interests lies is a foundational component of basic research. Efforts by the media and politicians to disparage the work of peer-reviewed scientist is an attack on free inquiry and threaten truly groundbreaking discovery. Scores of research projects that may have seemed trivial have led to some of the most important scientific discoveries.
- **Access to higher education should be based on ability, not circumstance.** Of the three core principles, this is where we are most deficient. UC Riverside stands as a national model for student success for access to higher education. UC Riverside’s efforts have improved the outcomes of lowest-income and underrepresented minority students.
- The vision for government-led research still guides our basic research efforts, but we remain woefully inadequate on the third core principle—access to higher education. The graduation rates for minorities and Pell grant recipients remain low and family income is the main factor for who succeeds at the college-level. We need to replicate the successes of those institutions that defied these trends to realize the larger societal benefits and bolster the research enterprise vital to our nation and the world.

The Knowledge Archive as Convergence: Challenges of Scale and Sustainability for Scholarly Publishers, Libraries and Museums

Alex W. Barker, Director, Museum of Art and Archaeology, University of Missouri

- Museums and libraries both hold and offer access to growing amounts of information about objects—paper, digital, or dimensional—whose value is directly related to their accessibility or findability. Both play key roles in the archiving, presentation and preservation of knowledge, what has been called the knowledge archive.
- Rates of growth of archives in museums and academic publishing are staggering. There is increasing value to publishers in expanding the number of contributions published. The same pressures are at work at museums. Another trend is the equal concern with datasets on which research is based, to promote secondary research and to promote validation of data and conclusions. The demand for open access is another trend that poses challenges to most forms of academic publishing and less-advantaged scholars find it harder to contribute, because of the cost. The implications that emerge from these trends include massive increase in curated content, a shift in authority from editors to readers, and the erosion of the traditional forms of aggregation.
- As external pressures are forcing convergence between publishers, libraries and museums, new synergies are emerging, and old distinctions borne of legacy print-based workflows are blurring. Time will tell how robust those synergies will be, and in the meantime, they offer opportunity for scholarly inquiry and implications for research infrastructure.

Child Trauma Research: Future Directions and Next Steps

Yo Jackson, Professor and Senior Scientist, Clinical Child Psychology Program/Life Span Institute, University of Kansas

- The SPARK project, a five-year longitudinal study funded by the National Institutes of Health, is an example of a large-scale effort that follow youth and their development over time. Research on youth exposure to trauma is most often directed toward the study of the rate, nature, and outcome of experiencing atypical events during development. The relation between exposure to trauma in childhood and negative health outcomes is not, however, automatic and the study of resilience seeks to determine under what conditions do youth exposed to trauma progress typically and demonstrate expected developmental milestones across social, academic, physical, emotional, and behavioral health domains.
- To access youth in foster care for research, SPARK staff had to create working relationships with a myriad of stakeholders including the State of Missouri to gain access to the youth, as well obtain each child's case file. The staff also met and developed relationships with others, making the process time and labor intensive. The SPARK project

collected data from youth and foster parents on over 2,000 variables, while ensuring the well-being of participants.

- Data collection for the SPARK project was complete in 2015 and the staff has 10 published studies and over 15 conference presentations as a result. Though the big model is still in progress, preliminary results are available. Youth who demonstrate adaptive functioning do not have less exposure to trauma, nor are they better copers or more intelligent or have more social support. Those who fare poorly tend to have more family support, interpret trauma in a rigid manner, and tend to cope with trauma by avoiding it or enlisting the help of others.
- Projects like SPARK are not possible without the support from the university. Most beneficial to the SPARK investigator were having release time and support from the university infrastructure. As the role of community-based research at universities continues, administrators may do well to expand their definitions of faculty productivity and student success and include activities where students can get involved in projects that serve the broader community.

Technology and Research

Hannes Devos, Assistant Professor, Department of Physical Therapy and Rehabilitation Science, School of Health Professions, University of Kansas Medical Center

Abiodun Akinwuntan, Dean and Professor, School of Health Professions, University of Kansas Medical Center

- The effective transmission of knowledge has led to significant advancements in technology, which has continued to revolutionize virtually every aspect of the world we live in today. For accurate transmission of technological knowledge, research is needed.
- Driving has become a primary necessity and it is an instrumental activity of daily living. Though, it is a high-risk activity with safety implications. There has been research focused on developing methods to assess and retrain drivers who have a medical condition that affects their ability to drive. Until the 1980s, assessment and retraining of these drivers took place in real cars on real roads. Researchers and clinicians have looked for safer, cheaper, and more effective technological alternatives to the on-road testing.
- Driving simulators provide an opportunity to assess and retrain affected drivers. Simulator-based assessment and intervention now offer near-realistic driving situations that allows the researchers and driving experts a better opportunity to assess and retrain.

- In the future, we plan to look at the benefits of measuring cognitive workload while performing different cognitive tasks of varying levels of difficulty in the driving simulator. Detection of abnormal changes in workload may provide early detection of cognitive decline. This can lead to interventions, which will decline progression of disease rate and prolong highest quality of life.
- To keep the vehicle of technological advancements going, it is important for universities and the industry to continue to engage in scientific partnerships. These partnerships will benefit from establishing clear agreements, effective communication, and well-defined expectations.

Animal Research Support: The Transition from Ancillary Service to Contract Research Organization

Jerry Zamzow, Assistant Vice President for Research, Iowa State University

- The use of animals in research, a vital component for advancing the human condition, is controversial at times. Public perception of the use of animals in research has shifted recently, and institutions are assuming much of the responsibility. Centralization is a mechanism that institutions are using to meet regulatory aspects, mitigate questionable research practices and reduce bias.
- The model of a Central Research Organization (CRO) is an opportunity for an institution and research offices to provide a greater level of service to principal investigators and their research. The CRO would be a one-stop shop, providing assistance in study design, development of standard operating procedures, implementing activities, and returning results.
- There are pros and cons to the CRO model. Institutional risk is mitigated by having highly trained staff involved in all areas of the study. By centrally managing the process, studies are carried out with greater confidence in regulatory and ethical integrity. CROs provide cost savings and a reduction in administrative burden for principal investigators. A negative aspect is the loss of teaching opportunity. A financial investment in the model must be made, and may not be recouped for some time, though with proper changes, the CRO will be self-sustaining, and provide a greater level of service to investigators.

The Value added of Education at a Public Research University

April C. Mason, Provost and Senior Vice President, Kansas State University

- The classification system for universities is important, and Kansas State is a very high research university. Its rankings are monitored by growth in research dollars and faculty are nominated for national awards by this category. Universities value the success of students and faculty and staff work to help students. In addition, these universities have many programs in place to help students succeed.

- Kansas legislature recently passed a law that requires public universities make available the cost of an education, time to degree, and expected salary, to determine the return on investment of an education. Although the data is flawed in most cases, the return on investments for degrees from research publics in state compared to lower research universities are not favorable. Public research universities will need to compete on the value added of an education at a public research university.
- Strategic thinking, planning and action are more important than at any other time in history of public research university education. These universities are going to have to demonstrate why an education from a research university is important, and this will include clearly communicating what they are and are not. They will need to ask what can be done to make the educational degree from the public research universities mean more, value more, help more and better prepare students.

Assessing Research Productivity

Sara Thomas Rosen, Dean of Arts and Sciences, Georgia State University

- Research universities aspire to excellence in research and scholarship, which creates additional responsibilities for administrators. The best decision for research and scholarship should be data-driven. This paper demonstrates the value of data about faculty activity by working through data from the University of Kansas. It extends on recommendations by Dr. Steinmetz at the 2014 Merrill Retreat, and shows how to use productivity data to identify factors that influence productivity.
- This paper examines eleven measures of faculty scholarly productivity. It compares the University of Kansas (KU) to ten peer institutions. Additionally, nine departments were selected for analysis. Tables and graphs summarizing faculty productivity within nine departments at eleven institutions were created and the examination of the results found three KU departments for which the results pointed to interesting patterns of productivity.
- The analysis of the Academic Analytics data for one department out of the KU social-behavioral sciences (SSI) sector indicate the need to identify and correct the hiring and promotion practices that have led to non-productive faculty. Analysis of the data show that faculty in one of the departments of KU's natural science (NSI) sector are active in publishing and grant activity, but the work has a minimal impact on the field. This finding suggests the need for an external review team to examine the NSI department's research activity and determine why the research impact is low. The individual data from the third KU department out of the humanities (HI) sector, reveal that half the faculty have been producing the majority of the department's output.
- The data shows that, with one department exception, KU faculty have put their time, effort and resources into articles that are rarely cited. The University's efforts to raise citation's scores include hiring foundation professors who bring their citation with them, and having

faculty provide open access to their publications, which generally increases citations. Although these are useful, increasing citation scores will require centrally led, department-by-department analyses of how KU hires, mentors, and promotes its faculty.

Planning for Institutional Core Research Facilities in Uncertain Times

Joseph A. Heppert, Associate Vice Chancellor for Research, Professor of Chemistry
University of Kansas

- Public universities are challenged with creating a sustainable system of core research laboratories that serve the largest possible group of investigators. In spite of capital costs and support for research personnel, core research laboratories enhance the university's research efficiency. Federal agencies have also come to realize the advantages of centralizing core resources.
- KU began to build core labs in the early 1970's and KU research currently supports and administers ten core laboratories. Building a culture around the development and use of institutional core laboratories requires an institutional commitment for support, principal investigators' support, and a strategy for optimizing laboratory function. Suggested best practices for creating a robust system of core research laboratories include cost effectiveness, sustainability, adaptability, responsiveness, engagement and outreach.
- At the University of Kansas in Lawrence, the understanding of these best practices in management of the core research labs was applied in the conceptualization and design of the new multi-user nanomaterials clean room core facility. Initially, KU had project plans of clean room spaces at three sites on campus. Instead, KU chose to close the existing facilities and build a single 5,000 square foot multi-user space and an associated 2,000 square foot dedicated cleanroom space centrally located. The state-of-art facility will be widely used by KU researchers and marketed for use by private sector partners. Professor Steve Soper, recently hired by KU, will make heavy use of the new clean room core with his research programs for cancer and other human diseases.

Enhancing University Research Through Innovations in Graduate Education

Sarah C. Larsen, Associate Dean, Graduate College, Professor, Department of Chemistry, University of Iowa

- Graduate education plays a key role in university research infrastructure at universities in the United States. Research experience is essential to the doctoral degree and is connected to the university research enterprise and faculty productivity, particularly in Science, Technology, Engineering and Mathematics (STEM). Graduate students are a critical component of the human capital supporting university research and innovation.
- However, graduate education is not immune to the challenges faced by all of higher education. Challenges in graduate education include financial support, diversity and inclusion, career training and transparency. Financial support is a critical factor contributing to degree completion. There remain concerns about completion, climate, and inclusiveness for underrepresented minorities. About one-half of doctoral graduates go onto to careers outside of academia, where their employers believe they have the research skills, yet are deficient in other skills necessary to succeed.
- Recommendations to meet the challenges are offered. Universities should engage in discussions with private donors, federal funding agencies, and industrial partners to provide financial resources of support for students. In addition to recruiting and admissions considerations related to diversity, there is a need for increased retention and completion efforts to support underrepresented minority graduate students. With decreased tenure track academic positions available for those earning doctoral degrees, there is a need for graduate colleges to provide students with early exposure to career pathways and enhanced professional development opportunities to better prepare students for academic and non-academic careers. Through these innovations in graduate education, the research mission of the university will be increased.

Infrastructure Planning and Implementation for Transformative and Incremental Research

Brian Foster, Provost Emeritus, Emeritus Professor of Anthropology
University of Missouri

- Transformative research provides the most prestige to the researcher and the institution, but it is very unpredictable, and results are long term. All serious research institutions aspire to transformative research outcomes; the question is how institutions build the infrastructure for unpredictable, long-term research results, especially in view of academic traditions like promotion and tenure, hiring practices, and institutional productivity metrics.

- Predictability of infrastructure needs is an important element in the planning of infrastructure. Yet, research is a creative act. Because it is a creative activity, capturing the needs of doing something that has not been done before is problematic. Research takes many forms that vary according to disciplines. An important difference that cuts across all disciplines is transformative versus incremental research.
- Given the broad perspective on infrastructure, high-level infrastructure is likely to be in areas of special institutional strength. The University of Missouri has several major facilities and assets that support both incremental research and provide recruitment opportunities to attract those interested in transformative research in those areas. This paper presents five unique initiatives: a very strong nuclear reactor, a research center closely linked to the functions of the reactor, an interdisciplinary group that does research and clinical services, an institute that deals with research on the future of “journalism,” and a creative facility for independent senior living. Another initiative with a focus on issues of democracy, anchored primarily in the humanities and social sciences is discussed.
- The six initiatives at the University of Missouri have potential, five having moved far along the transformative research continuum. Most important is the broad range of contributions these highly successful initiatives have produced. Infrastructure has been the key element of success for each of the initiatives. Without significant infrastructure, these initiatives would not have come to where they are. These initiatives would not have achieved the necessary infrastructure without significant external resources, and in one case, institutional commitment to bring a transformative research program to the University.

Seed Funding Programs in a Comprehensive Liberal Arts and Sciences College

Carl W. Lejuez, Dean, College of Liberal Arts & Sciences, University of Kansas

Jessica Beeson, Director of Research and Engagement, College of Liberal Arts & Sciences, University of Kansas

Maureen Cole, Assistant Director of Research and Engagement, College of Liberal Arts & Sciences, University of Kansas

- Seed funding is crucial to the success and growth of a college of liberal arts and sciences. This paper explores commonalities and differences in seed programs within and across universities, reviews a case study from the University of Maryland, and discusses key considerations in implementing a seed fund program.
- Based on a survey of ten college deans to address how seed funding is undertaken at similar institutions, we identified common features of seed-funding programs. Two common rationale for seed funding include building interdisciplinary bridges and supporting single investigators. The survey results show that seed funding had an impact on faculty morale. There was a greater focus on seed funding for the sciences, and some

deans suggested separate allocations to ensure support for the art and humanities. Survey results also indicate that there is not one common way to administer a seed fund program and the allocation of funds vary.

- The case study of the seed funding program at the college of behavioral and social sciences (BSOS) at the University of Maryland provides an analysis of a seed funding initiative. Though the initial BSOS seed funding investment had a positive influence on research funding and faculty morale, the program lacked structure and strategic direction. Carl Lejuez, the paper's first author and former associate dean for research at the University of Maryland, revamped the BSOS program to strengthen and clarify goals, categories and allocation, selection process, metrics, and reporting and evaluation. The overhaul of the program had a dramatic impact on the return on investment, in terms of research output, staff and students hired and receiving significant development experiences, and the overall prestige of the unit.
- When developed and conducted in a strategic manner, seed funding can be an essential part of the research mission of a comprehensive liberal arts and sciences college. In times of budget uncertainty, creative strategies may be necessary to raise funds to develop seed programs. In fundraising efforts, it is important to articulate how research builds the prestige of the institution and has an impact on the education mission for students. There can be value in integrating nontraditional seed funding approaches into more traditional seed programs.

Staying Strong and Healthy: Minimizing Cardiovascular and Metabolic Effects of Androgen Deprivation Therapy: A Study in Transition

Sally Maliski, Dean and Professor, School of Nursing, University of Kansas Medical Center

Elisabeth Hicks, Research Associate, Oregon Health and Sciences University (OHSU) Family Medicine

Alana Enslein, Research Manager, University of Kansas School of Nursing

- This paper describes the NIH-funded randomized controlled trial of intervention to minimize cardiovascular and metabolic risk for Latino men on androgen deprivation therapy (ADT), used to treat prostate cancer. The method for the study included recruiting Latino men who initiated ADT within the past three months and randomizing the men into control and intervention groups. The procedure included taking baseline measures that were repeated at 6 and 12 months.
- Participants assigned to the intervention group received smartphones, as well individualized exercise and nutrition plans and goals. These men and their significant others received weekly calls from the study nurse and cultural liaison for three months that included an educational, activity and nutrition component. During the next three months, men received monthly calls from the cultural liaison to monitor, assist and

coach the nutrition and activity plans. There is no contact between six and 12-month data collection visits.

- Subsamples from each group were interviewed about their choices for food selections and exercise. Interviewers asked the men in the intervention group about their experience of the interventions. A constructivist grounded theory approach is being used for this portion of the study to explore differences in decision-making processes related to nutrition and activity between the two groups. Analysis will include both quantitative and qualitative techniques.
- At this point, the study is in transition between two major universities, which is a lengthy and complex process. In the transition, several issues needed to be identified including resources, technology, and recruitment of participants. Mechanisms for transfer of data collection procedure, documentation, tracking, storage and management had to be developed. Additionally, study equipment had to be moved to the new institution. Close and open communication amongst all parties, including NIH and the universities, has been important to a successful grant transition.

Attracting and Retaining Competitive Faculty – Startups, Core Facilities, and Investment Strategies...Oh My!

Peter K. Dorhout, Vice President for Research, Kansas State University

- A key factor in meeting Kansas State's goal of a Top 50 Public Research University by 2025 is the ability to grow the research enterprise through focused investments in core facilities and institutional support structures that will enable faculty to be competitive for extramural funding, particularly in interdisciplinary and inter-institutional grant programs. Startups, core facilities, and investment strategies for research are the keys to attracting and retaining competitive faculty. In an environment of diminishing state appropriations for higher education, it has become critical to develop strategies to fund startups that will support new hires or retain key members.
- Startups, core facilities, and investments...oh my. This was a recurrent chant for the Vice President of Research at Kansas State during his first six months on the job. He was reminded of a famous journey for a young girl in Kansas, and the challenges facing the film studios in the making of the movie, *The Wizard of Oz*.
- When leadership changes, as it did when the Director of *The Wizard of Oz* left, some questioned the "screenplay", which can be compared to the strategic plan at the university. The Strategic Plan for transforming any organization, like the screenplay for *Oz*, is only as good as the talent it guides and the leadership that embraces creativity and finds a path forward.

- Investments are unique to each institution, but they reach back to the screenplay and ultimate goal. For Kansas State, that goal is to be at Top 50. The research enterprise at K-State can be enhanced by embracing industry partnerships, which also aligns with the land-grant institution mission to bring knowledge to the public. With diminishing state resources, investing in core facilities and recruiting and retaining faculty is challenging. A change to a shared facilities model can be for the good.
- The journey of the making of *The Wizard of Oz* serves as a good metaphor for the coming-of-age for the research enterprise. The journey at Kanas State is one that is focused on improving our part of the world, changing for the better so students and faculty will prevail, because there really is no place like home.

Clearing the Path on the *Endless Frontier*

Kim A. Wilcox, Chancellor, University of California, Riverside

“**N**ew frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life.”

--Franklin D. Roosevelt
Letter to Vannevar Bush
November 17, 1944

As World War II neared its end, President Franklin Roosevelt wrote to Dr. Vannevar Bush, head of the Office of Scientific Research and Development and former dean of the MIT School of Engineering. President Roosevelt tasked him with formulating a strategy for postwar federal support of scientific research that built on the successes seen during wartime. With the help of four committees of scientists and scholars, Dr. Bush produced the seminal *Science: The Endless Frontier*.

Recognizing the need for a formal national strategy of scientific research, Dr. Bush and his collaborators laid out a plan for a federal agency focused on promoting research. Five years later, his proposal was partially realized in the creation of the National Science Foundation. The principles outlined by Bush in 1945 have guided federal support of basic research ever since.

Among his recommendations, were three core principles:

- the federal government should fund basic research through the nation's universities;
- free inquiry is essential to the creation of new knowledge;
- access to higher education should be based on ability, not circumstance.

In order to build research infrastructure and plan for future needs, it is essential that these three core pillars be integral to the U.S. research enterprise. While the first two principles have largely defined

the U.S. research enterprise, with notable exceptions, there is still considerable work to be done in broadening access to higher education, particular at the graduate level.

I. Introduction

Dr. Bush's insights into building a national research strategy were borne from a career as an academician, scientist, and administrator. Recognized for his engineering work in data retrieval that presaged modern computing, he was most noted for his role in guiding the U.S. research enterprise that was vital in World War II. After six years as dean at MIT, Bush was named as director of the prestigious Carnegie Institution of Washington, a major funder of research nationally. Once in Washington, D.C., he approached the White House about improving the nation's scientific research. In 1940, he proposed and was named chairman of the National Defense Research Committee (NDRC), charged with coordinating wartime research. In 1942, he

was named director of the newly formed Office of Scientific Research and Development (OSRD) where he shepherded the creation of radar and facilitated creation of the Manhattan Project (the “Uranium Committee” had been under his supervision at both NDRC and OSRD), among other projects. In plaudits not usually reserved for Washington bureaucrats, Bush received considerable notoriety for his role during the war. A 1942 article on Collier’s magazine called him, “the man who may win the war,” and he appeared on the cover of Time magazine in 1944 under the headline, “The General of Physics.”¹

Prompted by Vice President Henry Wallace, a friend and neighbor of Bush, President Roosevelt asked Bush for a formal strategy on applying the lessons of wartime research to postwar federal support of science. *Science: The Endless Frontier* laid out the framework for the modern research enterprise with focus on federal support of basic research conducted by universities. This vision was partially realized in 1950 with the passing of the National Science Foundation Act of 1950, which created NSF. *Science: The Endless Frontier* has proven to be an immensely prescient document that could not have foreseen but still managed to facilitate the world-changing scientific and technological developments that have defined the last 70 years. The broad use of nuclear energy, the space race and the invention of the Internet all point to the framework of research support ideated by Bush and his collaborators.² He noted at the time of writing the lack of a formal body charged with developing national science policy as well as the absence of standing committees in Congress charged with this

task. In addition to formulating a national research strategy, Bush’s work was instrumental in putting the concept of “basic research” into the national consciousness. An analysis by Roger Pielke Jr at the University of Colorado, Boulder, documented the number of times the phrase “basic research” appeared in *The New York Times*, *Science* and *Nature* over the course of the twentieth century.³ Prior to publication of the report, the term was almost nonexistent, even in the scientific journals, but within 13 years of the report’s publication, mentions in *The New York Times* alone had gone from 4 in 1944 to 159 in 1957.

II. Federal support of university research

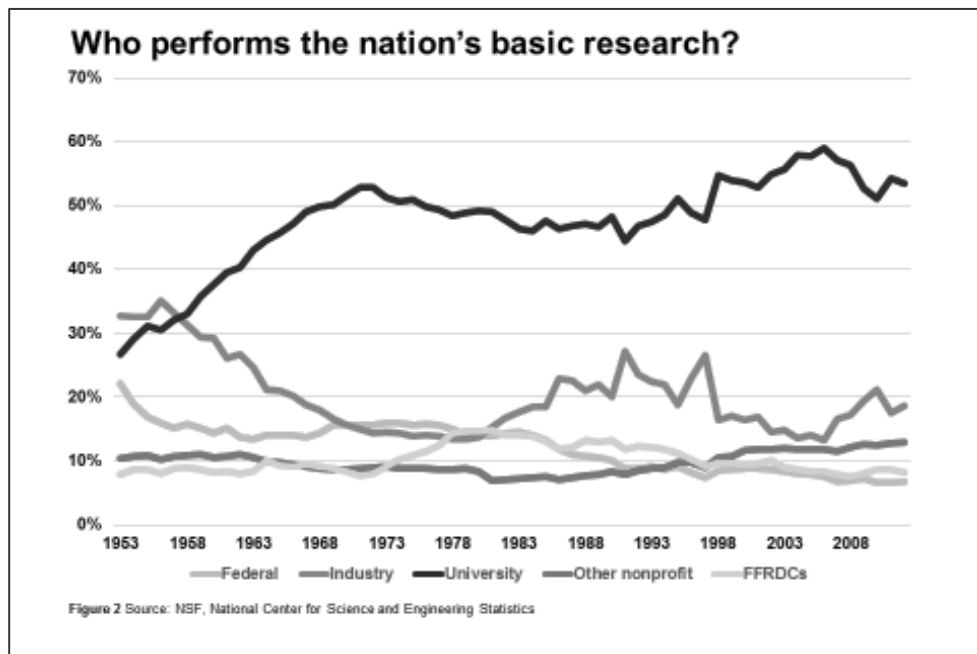
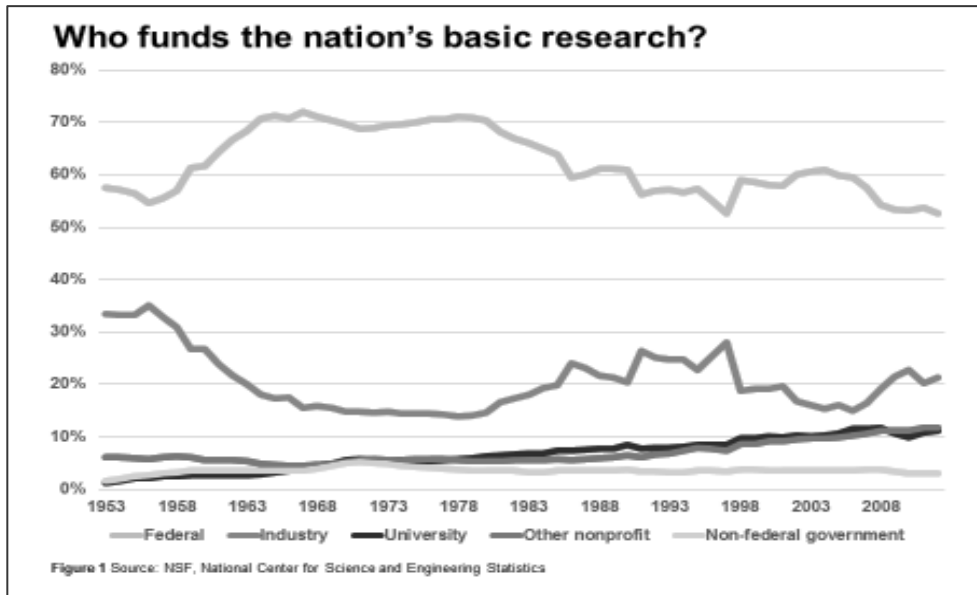
“The publicly and privately supported colleges, universities, and research institutes are the centers of basic research. They are the wellsprings of knowledge and understanding. As long as they are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems . . .” *Science: The Endless Frontier*, p. 12

Federal funding of research universities is the bedrock of basic research in the U.S. Having managed massive government-funded research enterprises, Bush recognized that only the federal government could marshal the necessary resources to adequately support research efforts that would result in major discoveries and innovations. Likewise, as a former university administrator, Bush understood that universities were uniquely qualified to perform basic research.

While government and industry are more focused on applied science, Bush argued that universities, along with a

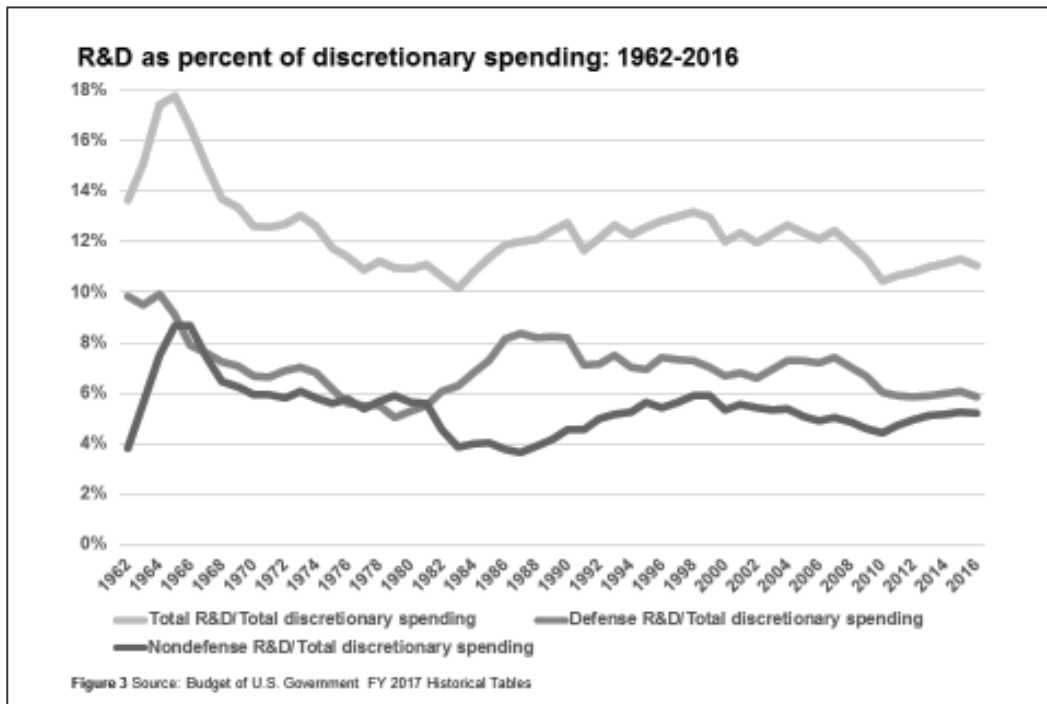
few research institutes, were the entities most devoted to “expanding the frontiers of knowledge.” Figures 1 and 2 demonstrate how funding and research patterns have closely followed Bush’s conclusion. Since 1953, the federal gov-

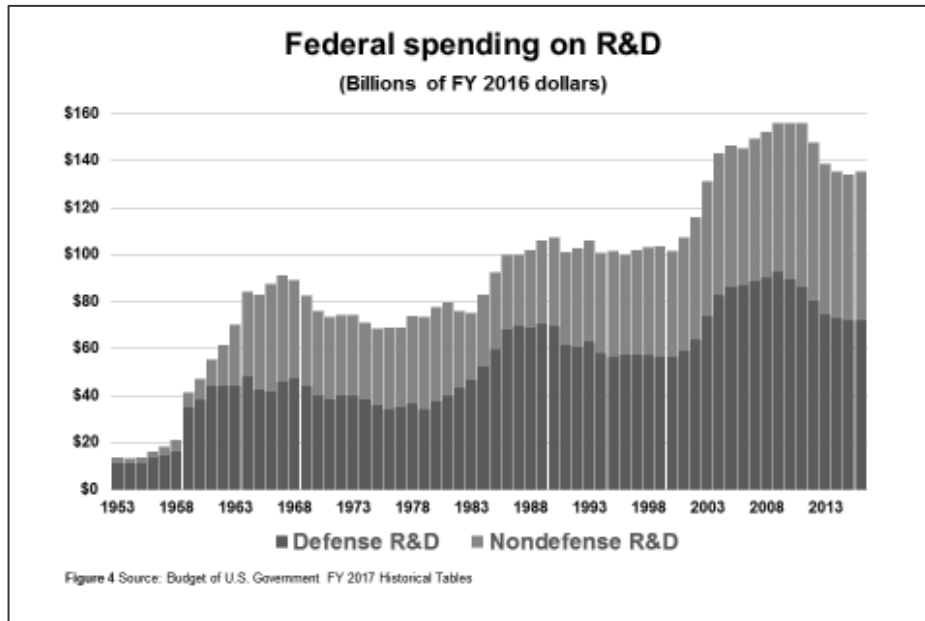
ernment has provided over 50 percent of the nation’s expenditures on basic research, with some year’s surpassing 70 percent. Likewise, the majority of that funding is going to universities, hovering above 50 percent in recent years (Figure 2).



Generally speaking, federal support of basic research enjoys broad support among the American public. In a Pew Research Center study released in 2016, 71 percent of respondents agreed that government investment in basic science research pays off in the long run.⁴ This public perception is reflected in the generally steady federal funding of basic research. Figure 3 delineates the percentage of U.S. federal discretionary spending dedicated to research and development since 1962. Except for significant increases in the mid-1960s, federal support of research and development has varied between 4 and 6 percent of discretionary spending. Figure 4 represents spending in FY 2016 dollars on research and development since 1953. While the overall trend of the last 60 years is positive, the recent decline

followed by stagnated funding stands as a real challenge for the nation's research universities. The automatic funding cuts included as part of the 2013 budget sequestration were particularly deleterious to U.S. research efforts. The Chronicle of Higher Education surveyed 11,000 NIH and NSF grant principal investigators in 2014 about the effects of sequestration. Nearly half had abandoned an area of investigation they considered critical to their lab's mission and more than three-quarters fired or failed to hire grad students and research fellows.⁵ Inconsistent funding as seen in the last few years not only affects the research itself but also narrows the pipeline for early career investigators who represent the next generation of researchers.





II: Free Inquiry

“Scientific Progress on a broad front results from the free play of free intellects working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown. Freedom of inquiry must be preserved under any plan of Government support . . .”

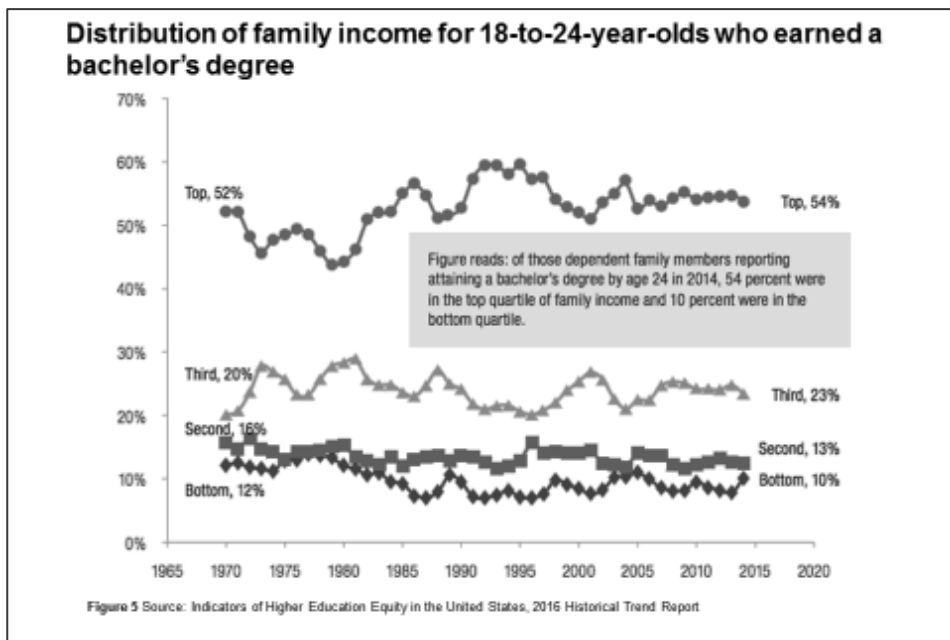
Science: The Endless Frontier, p. 12

Fundamental to Bush’s argument is the conclusion that freedom of inquiry is essential to expand the frontiers of scientific knowledge. The “free play of free intellects,” as he termed it, had to be preserved under any plan for government support of science. His report was published at the end of World War II when selling the idea of “basic research” to both public and politicians was relatively easy considering the immediate evidence of seemingly arcane scientific discovery leading to development of the atom bomb, radar and penicillin. The peer review process has been critical in balancing the need to be accountable

with taxpayer funds while also allowing for researchers to pursue knowledge wherever it may be found.

Unfortunately, some politicians and media have taken to disparaging the work of peer-reviewed scientists as silly and wasteful.⁶ These efforts are an attack on free inquiry and threaten to turn the U.S. research enterprise into an effort that can only achieve innovation on the edges of discovery, rather than realizing truly groundbreaking discovery. Much of the political ire has been directed at efforts in the social and behavioral sciences. It is important to note that behavioral and social factors are responsible for more than 50 percent of the preventable injuries, illness and deaths in the U.S. Bush also argued this point, calling it “folly” to pursue the natural sciences and medicine at the cost of the social sciences and humanities.

The freedom to pursue knowledge wherever interests lie is a foundational component of basic research. Scores of seemingly esoteric, trivial or silly sounding research projects have led to some of



the most important scientific discoveries and innovations. Genomic studies of nematode worms have identified genes critical in new cancer and Alzheimer’s treatments. GPS exists because of research in atomic physics. In 1995, two grad students at Stanford were working on the NSF-supported Digital Library Project. They were working on an early search engine that they called “BackRub.” The seemingly unserious sounding BackRub became Google, the brainchild of two students, Larry Page and Sergey Brin.

IV: Broadening educational opportunities

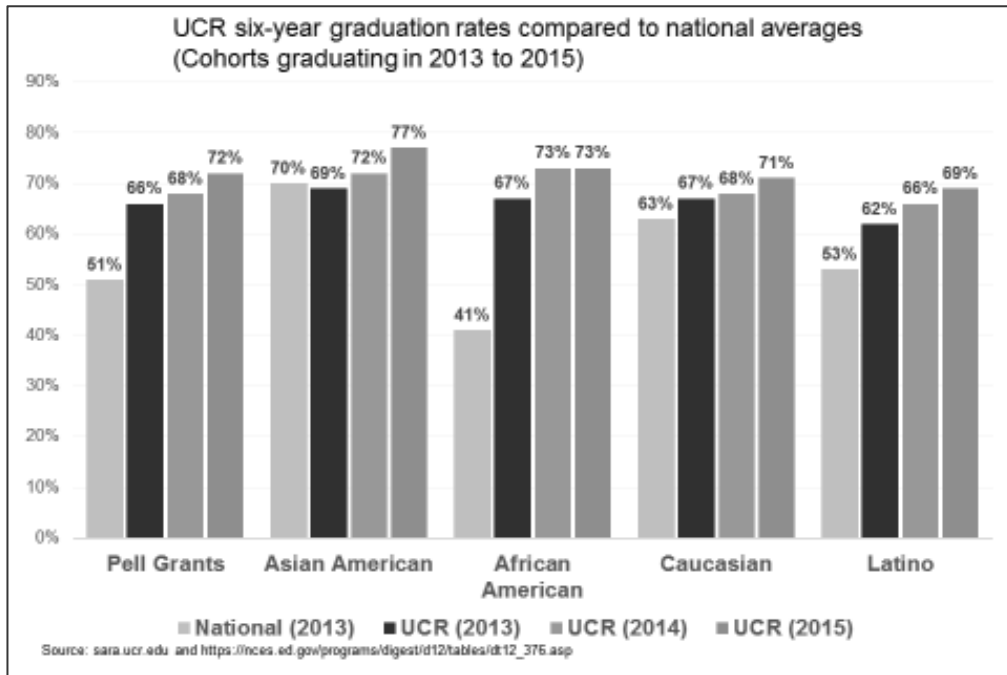
“There are talented individuals in every segment of the population, but with few exceptions those without the means of buying higher education go without it. Here is a tremendous waste of the greatest resource of a nation—the intelligence of its citizens”

Science: The Endless Frontier, p. 25

Of Bush’s three core principles of a government-supported research enterprise, the third—broadening educational

opportunities—is where we are most deficient. Figure 5 represents the distribution of family income among 18-to-24-year-olds who earned a bachelor’s degree. It is striking that more than half of all degrees go to individuals from the top quartile of family income while only 10 percent of degrees go to those from the lowest earning quartile. Clearly, these data are cause for concern on a variety of levels. The fact that family income still stands as a prime determining factor for whether someone will graduate from college holds not only a variety of social and economic consequences but also represents a headwind to our efforts to realize discovery and innovation through basic research. As Bush terms it, by not broadening access to higher education, we are wasting our “greatest resource.”

A causal factor for the income disparity among college graduates is that when low-income students enroll in colleges and universities, they are far less likely to graduate compared to their more affluent peers. Figure 6 compares national six-



year graduation rates with the graduation rates at UC Riverside by Pell Grant status and race/ethnicity. UC Riverside is unique nationally among research institutions in that there aren't any graduation rate gaps across income and race/ethnicity categories. Likewise, UC Riverside has raised graduation rates campus-wide by 10 percent over the last three years.

Due to our record of student success, UC Riverside stands as a national model and a number of our efforts warrant mentioning here.

- First of all, you can't improve outcomes of low-income and underrepresented minority students (URM) without enrolling them first. In the mid-1990s, UC Riverside made a commitment to become the most diverse, high-achieving research university in the country. That goal defines our university today. Based on our Fall 2015 enrollment data, 56 per-

cent of our undergraduate students are Pell Grant recipients and 86 percent of our domestic undergraduate population are students of color.

- We have roughly 75 programs that cover the full gamut of student success, from student retention to career development. We closely monitor the progress and success of each program and a committee meets regularly to discuss gaps in programming and facilitate evaluation.
- Learning communities gather small groups of students into formal cohorts who take many of the same classes and receive focused academic support. Since initiating the learning communities, we've seen retention rates grow by 6 to 8 percent annually, with particular success among low-income and first generation students.

Approximately two-thirds of our incoming first-year students participate in learning communities.

- Facilitating undergraduate research has been a boon to student success. More than 50 percent of our students report having engaged in faculty-mentored research during their time at UC Riverside. Our undergraduate research efforts have also proven to increase interest in pursuing graduate studies.

UC Riverside is also a founding member of the University Innovation Alliance (UIA). Founded in 2014, UIA is a consortium of 11 large public research universities committed to improving outcomes among low-income and minority students. UIA is also supported by five foundations, including the Bill & Melinda Gates and Ford foundations. We are identifying and piloting new innovations to improve student success and also scaling proven innovations that improve graduation rates. The UIA collaborative initiatives include:

- Predictive analytics and data-driven interventions
- Computer-based adaptive learning to tailor to students' needs
- Financial interventions such as financial literacy education and "just-in-time" grants
- Pre-college bridge programs that reach out to students as early as middle school
- Targeted student support that uses data to provide specific support to student subgroups

V: Conclusion

The Government should accept new responsibilities for promoting the flow of new scientific knowledge and the development of scientific talent in our youth. These responsibilities are the proper concern of Government, for they vitally affect our health, our jobs, and our national security.

Science: The Endless Frontier, p. 8

The vision for government-led research laid out by Vannevar Bush over 70 years ago still guides our efforts to realize discovery and achieve innovation, but considerable work still remains to reach the full potential envisioned by Bush. Out of the three core principles outlined by Bush for a successful program—federal support of university-based researchers, free inquiry, and expanded educational opportunities—we remain woefully inadequate on the third. As long as six-year graduation rates of Pell Grant recipients remain close to 50 percent and as long as only half of Latino/Hispanic students and less than half of African American students graduate in six years, we will continue to fall short of our potential in fostering research discoveries. And these figures only account for those students who make it to college in the first place. Additionally, income continues to stubbornly dictate to a large degree who succeeds at the college-level. While many institutions have proven capable of defying these trends, we need to replicate these successes on a massively larger scale not only to realize the much larger societal benefits but also bolster the research enterprise that has proven so beneficial to our nation and the world.

References

1. Dizikes, P. (2011). "A difference maker." MIT News. <http://news.mit.edu/2011/time-line-bush-0216>
2. Waterman, A. (1960). Introduction to Science: The Endless Frontier. Reprinted by the National Science Foundation.
3. Pielke, R. (2010). In Retrospect: Science—The Endless Frontier. Nature. Vol 466. August 2010.
4. American Institute of Physics (2015). Survey Finds Broad Public Support for Federal Basic Research Funding. <https://www.aip.org/fyi/2015/survey-finds-broad-public-support-federal-basic-research-funding>
5. Massachusetts Institute of Technology (2015). The Future Postponed: Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit.
6. Office of Senator Jeff Flake (2015). Wastebook: The Farce Awakens. <http://www.flake.senate.gov/public/cache/files/03714fa3-e01d-46a1-9c19-299533056741/wastebook---the-farce-awakens.pdf>

The Knowledge Archive as Convergence: Challenges of Scale and Sustainability for Scholarly Publishers, Libraries and Museums

Alex W. Barker, Director, Museum of Art and Archaeology,
University of Missouri

Museums and libraries are similar beasts. Both hold and offer access to growing amounts of information about objects—paper, digital, or dimensional—whose value is directly related to their accessibility or findability. Both also play key roles in the archiving, presentation and preservation of knowledge, what has been called the knowledge archive. That similarity of role is not accidental; some of the founding theorists of the American museum movement—men like John Cotton Dana—came from a library background, and envisioned both kinds of institutions as fulfilling the same societal role with differing kinds of objects. And that value was understood from the outset to be not simply educational or scholarly but social and economic—Melvil Dewey went so far as to name the first college of library science, established at Columbia in 1887, the School of Library Economy (Vann 1961:28).

As noted, they differ mainly in what kinds of objects they manage. Traditionally, at least, museums focused on specimens and artifacts, on art and dimensional ‘things’—while libraries focused on books, journals and documents, on paper and later film. Over the past several decades both kinds of institutions have converged, seeing their roles less in terms of solely managing the tangible items in their care and more in terms of managing the extant or potential information that those items convey, communicate or contain (Trant 2009; Bearman 2008).

For the most part that archive was formed through the efforts of scholars, who supported the production of knowledge through their publication of scholarship and creation of collections through research. Publication, largely via academic publishers, has long been viewed as both our primary means of dis-

seminating scholarship and simultaneously our surest and most effective method for archiving that knowledge. No single archive could systematize and collate all knowledge, and it is instead held in the back issues of thousands of different journals, held in multiple at myriad repositories and libraries, a distributed archive long before the internet made such concepts fashionable (European Bureau of Library, Information and Documentation Associations. 2009).

Museums similarly serve as archives for what we know about different aspects of the world. In natural history museums taxonomic type specimens—holotypes—backed up by the entire nomenclatural bestiary of secondary types—serve as a distributed archive across world museums of the organismal record of biological systematics, paralleling the published archive held by world libraries. In ar-

chaeological and anthropological museums, collections document cultural diversity and change, and through the careful comparison of objects and their seriation we came to define cultural sequences over broad areas and thousands of years long before the advent of radiocarbon or other chronometric techniques. And artistic traditions are founded and fixed on key museum objects perceived as central to or marking a fundamental change in the canon (Barker 2010).

Scholarship also played a key role in academic publishing, as the majority of journals were produced through scholarly societies, and their viability depended on both the volunteer labor of editors, assistant editors, reviewers, and others, and on subscription-based models funded by individual scholars and by institutions. The revenue models on which institutions like these were based are changing rapidly, and many once-solid foundations—of both the scholarly and financial kind—are eroding at a quickening pace.

Convergence of museums, libraries, and academic publishers (comprising memory institutions in the sense envisioned by Dempsey [2000]) is driven in part by the rapidly expanding scale of the archive. How quickly is it expanding? One recent study (Bornmann and Mutz 2015) found that the literature grew at less than 1% annually until the middle of the 18th century, by the period between the two world wars it had risen to 2-3% annually, and had risen to 8-9% by 2010. In practical terms, this means that the time needed for the total scholarly literature to double in size has become shorter and shorter. Now it doubles in volume

every decade—or less. Nor is this an outrageous result; previous bibliometric studies since 1965 have shown essentially the same trend (e.g., Price 1965, van Raan 2000; see also Riviera 2013). Using completely different methods, other researchers estimated that 1.35 million peer-reviewed papers were published annually by 2006, in line with a 2004 estimate by Elsevier to a parliamentary committee of 1.2 million peer-reviewed articles in science, technology and medicine (UK Parliament Select Committee on Science and Technology 2004).

In museums too, the growth of the archive is staggering. In the 1990s the federal Institute for Museum and Library Services estimated there were roughly 17,500 museums in the U.S., as of 2015 that number had doubled to 35,144. To put that number into perspective, today there are more museums in the U.S. than all Starbucks and McDonalds combined (Figure 1). And their collections are enormous. The National Park Service alone holds more than 63 million individual archaeological items, the larger Department of the Interior lists over 194 million as of February of this year, and the Smithsonian's website lists more than 138 million individually cataloged objects (Barker 2001, 2010).

And rates of growth are accelerating, as many academic publishers have moved from rejection rates (or selectivity) to citations (or impact) as the primary measure of quality, meaning there is increasing value to publishers in expanding the number of contributions published. Scale has become its own currency—the bigger the archive the more valuable—and as a result we see a trend toward fewer, much larger academic publishers,

as the more commercially viable presses either absorb or bankrupt smaller houses (Figure 2). The same pressures are at work in museums. For nearly two decades cultural heritage professionals have spoken of a “curation crisis,” (e.g., Childs 1995) as there are more collections being generated—both through research and compliance activities—than there are museum shelves to hold them, or curators to make sense of them.

The very range of anthropological holdings in museums—as a single apposite example—illustrates the complexity of the challenge, including everything from saliva samples held in freezers to pollen and phytolith samples documenting climate change over tens of thousands of years—and accompanying objects documenting how human societies dealt with those changes. They include prehistoric artifacts in their millions and unique objects like the intact Confederate submarine Hunley, or Ötzi the ice man, representative of the hundreds of thousands of human remains in world museums—even if he’s aged better than most. And work on any one of those myriad objects generates new objects to be tracked across all three kinds of archive (e.g., Barker 2001).

Another trend, now formally mandated by White House policy, is a shifting emphasis from the published results of research toward an equal concern with the datasets on which research is based, partly to promote synergistic or secondary research, partly to promote validation of data and conclusions, and partly to promote greater transparency and accountability. In 2013 the Office of Science and Technology Policy (OSTP 2013) di-

rected each federal agency funding research at significant levels to require researchers to provide detailed data management plans ensuring long-term access to all data resulting from sponsored research. In addition to preservation of and access to data from research projects, these data management plans often preserve metadata regarding the workflows associated with each dataset.

So where once we could differentiate between collections of objects on which research was done, processes of preparing, reviewing and publication of research, and access to and archiving of that research through libraries, all of those lines have now blurred. The raw data itself is now being archived, and in some cases published through peer review. OpenContext is an online initiative which aggregates, reviews and publishes research data and datasets rather than publications (Figure 3). Unlike online repositories like tDAR, OpenContext is aimed at the review and publication/dissemination—rather than long-term dark archiving—of research data, much of it based on physical objects in museums, or analytical datasets derived from such objects. Such programs further subvert and transform the boundaries between production, consumption and preservation.

Another obvious trend is the demand for open access. EU, the UK and White House directives mandate different levels of public access for any publicly funded research (e.g., OSTP 2013). While open access has gained many champions in recent years, it poses significant challenges to most forms of academic publishing, since to date it has only proven financially viable in a small number of

highly monetized disciplines, and instead of leveling the playing field for all scholars it has instead shifted the locus economic inequity. Instead of making it harder for less-advantaged scholars to access the archive (because of price), open access in its current forms effectively makes it harder for less-advantaged scholars to contribute to that archive (because of cost)—hardly a step forward (Figure 4).

Several implications emerge from these trends. First, because of reader overload (if naught else) we are likely to see a massive increase in curated content across academic publishers, libraries and museums. This includes both human-curated content—a trend we already see, largely supported through blogs, social media and other informal content providers—and algorithm based curation predicting other texts based on current selections. This also suggests a shift in authority from editors—who helped establish an intellectual space and voice for a given journal by grouping papers—to readers, who are increasingly able to select their own content, or select content based on curation by other individuals, aggregating content seamlessly across a range of titles.

This is made easier by another trend—the erosion of the traditional, legacy forms of aggregation. Print-based workflows aggregated content hierarchically by title, volume and issue, and groups of papers (selected by editors) appeared together in a single issue. While those trappings remain, articles are generally published online, separately, as soon as they've been accepted. Increasingly they're consumed not as groups of articles in a given issue, but as standalone

works retrieved by search, and major titles are moving from issue-based publication to continuous publishing models.

A further indication of this convergence is apparent in peer review. Once an early or initial element in the production of publications, it is increasingly expanding and becoming part of the archive of published research as well. Commercial publishers have long benefited from the volunteer labor of academic reviewers, but this too is becoming a revenue stream. Elsevier recently filed for a patent for its waterfall system of peer review, causing considerable disquiet among academics and proponents of more open systems (Blumenstyk 2016). Services like Rubriq (<https://www.rubriq.com/>) (Figure 5) provide presubmission, fee-based peer review, and some services like AXIOS Review (<https://axiosreview.org/>) offer pre-submission review and cascading submission programs which seek to place articles in multiple journals, ranked in preferred order. Peerage of Science (<https://www.peerageofscience.org/>), a free service, also allows pre-submission peer review, and some journals may accept such submissions based on external review in lieu of peer review by the journal itself.

The *Journal of Atmospheric Chemistry and Physics* (<http://www.atmospheric-chemistry-and-physics.net/>) (Figure 6) further blurs the boundary between production, consumption and archiving of knowledge through an iterative review process, where papers are submitted, referees comment, authors respond, the scientific community at large offers brief comments, the author revises, and the paper is published in journal format, with

all parts of the process being part of the public archive.

But while these trends are transforming the cycle of knowledge production, what of research completed before this integrative approach developed? Some initiatives are trying to reach back and salvage parts of the knowledge production cycle which would otherwise be lost. One example is GRSciColl, (Figure 7) an outgrowth of an older biodiversity collections registry, which is currently seeking to register all scientific research collections, including cultural collections. Part of its purpose is to provide unique collection identifiers that publishers could treat as authoritative pointers to the objects on which published papers are based. The initiative is community-curated, and anyone can add records and register collections. While crowd-sourced data of this kind present certain challenges in validation, they are already offering unexpected benefits. One longstanding problem in the knowledge production cycle has been that many collections are created by individual scholars, and when they die or retire the collections are orphaned, and may be lost. Through GRSciColl collections can be registered even if they aren't held by a museum or repository, and thus the Registry also serves an unintended function as a clearinghouse for information about collections which may be at risk, and a solution for departments inheriting orphaned collections when a faculty member retires or dies.

As external pressures like these force convergence between publishers, libraries and museums, new synergies are

emerging, and old distinctions borne of legacy print-based workflows are blurring. These synergies may yet dispel the old idea of forgotten specimens in museum basements, and dusty journals on creaky shelves remote from current intellectual discourse. But only time will tell how robust those synergies will prove to be, and in the meantime they offer fertile ground for both scholarly inquiry and implications for research infrastructure.

FIGURES

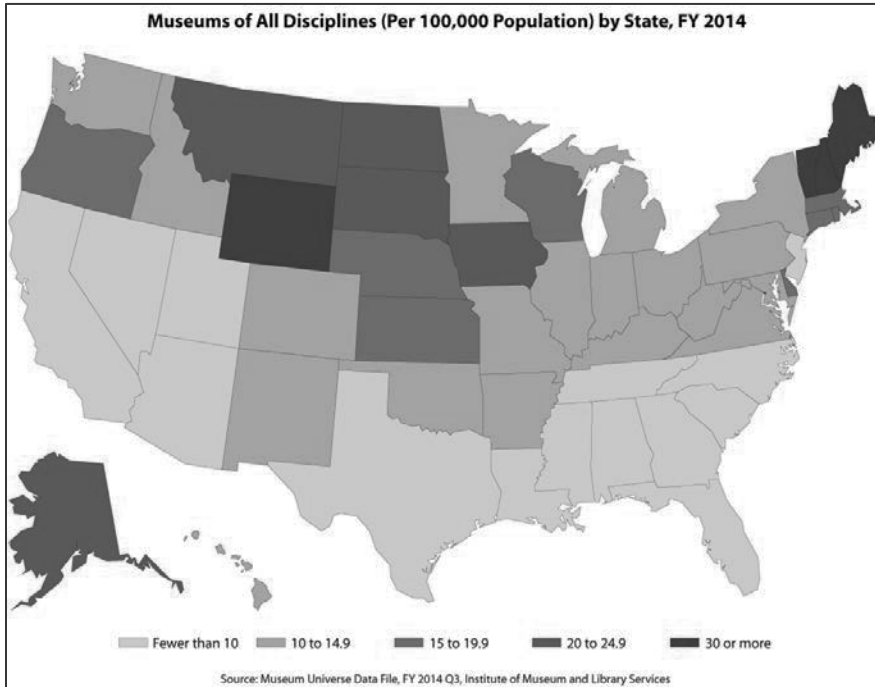


Figure 1: Density of Museums by Population, FY2014

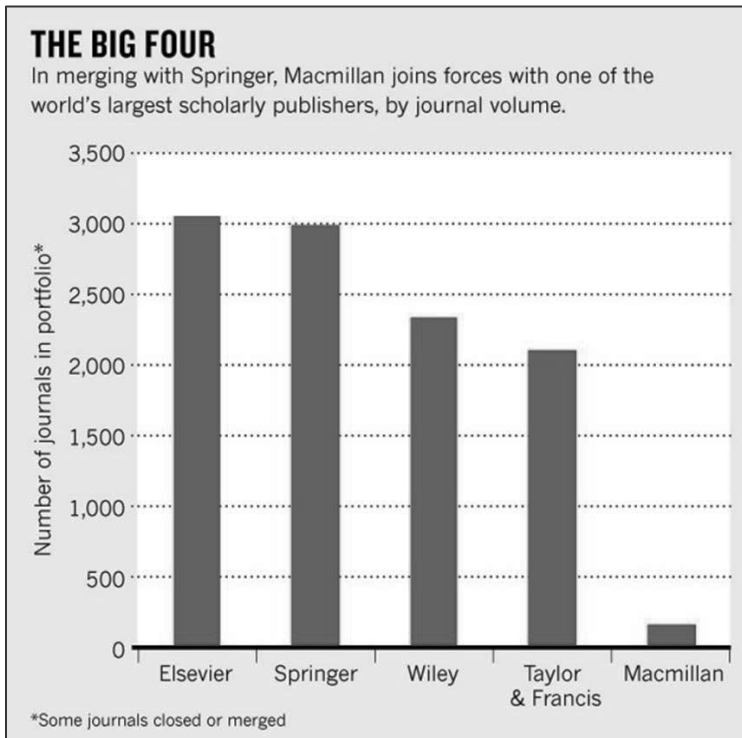


Figure 2: Fewer But Larger Academic Publishers (source Nature.com; <http://www.nature.com/news/nature-owner-merges-with-publishing-giant-1.16731>)

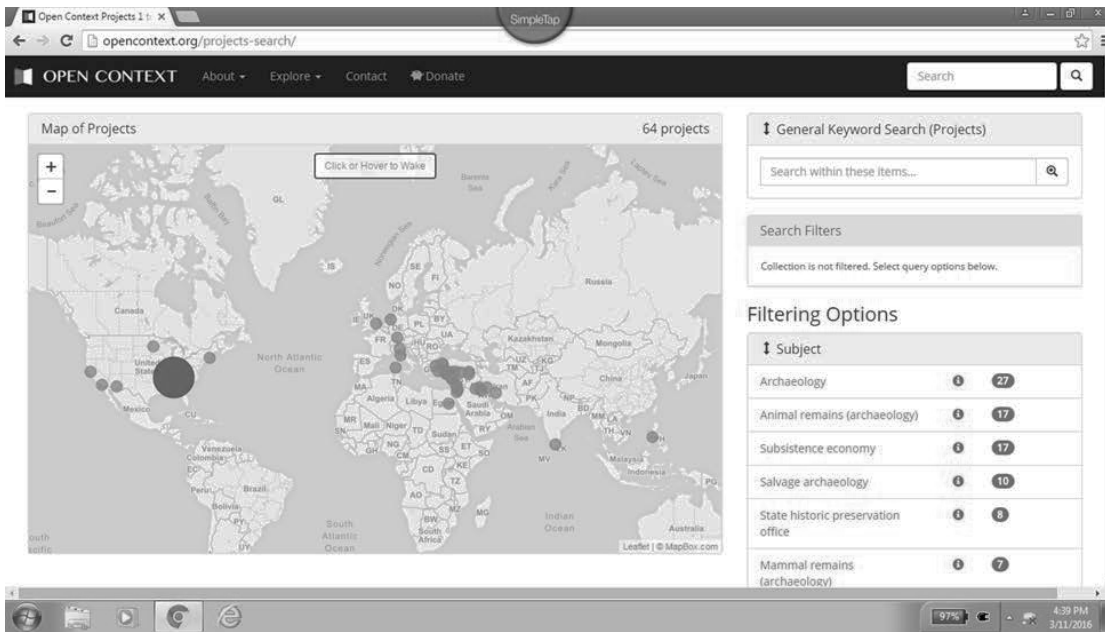


Figure 3: Open Context, an online publication venue for peer-reviewed data sets rather than publications in the more traditional sense.

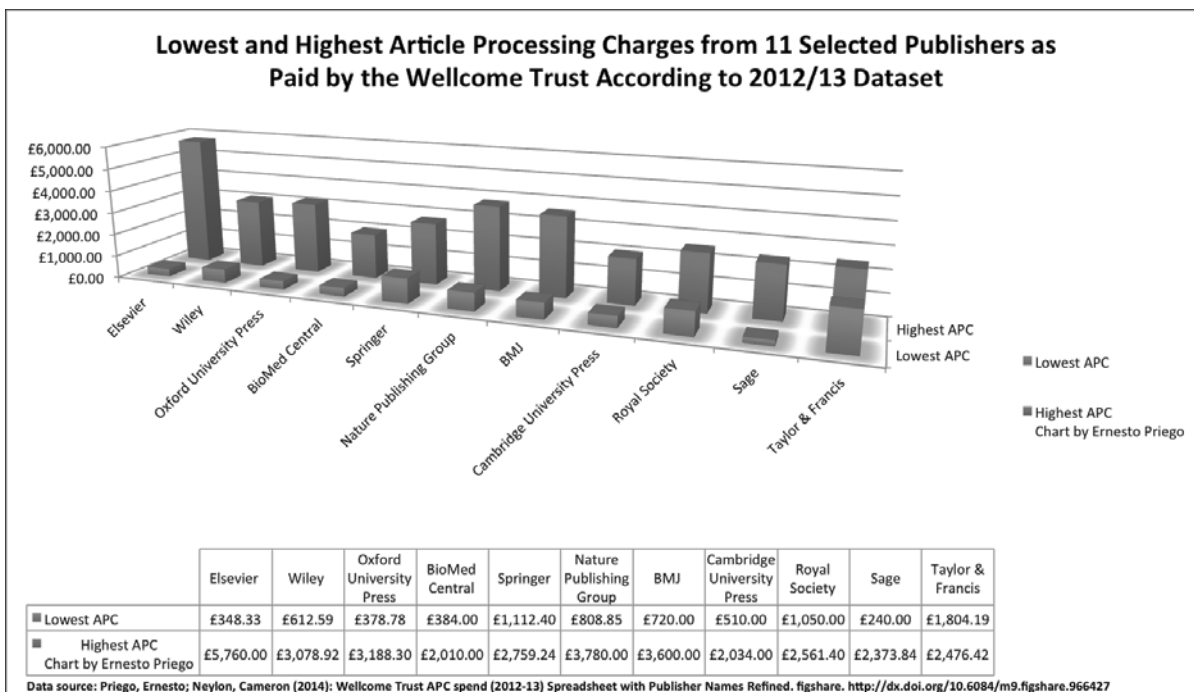


Figure 4: Range of Author Processing Charges (APCs) by Open Access Publishers

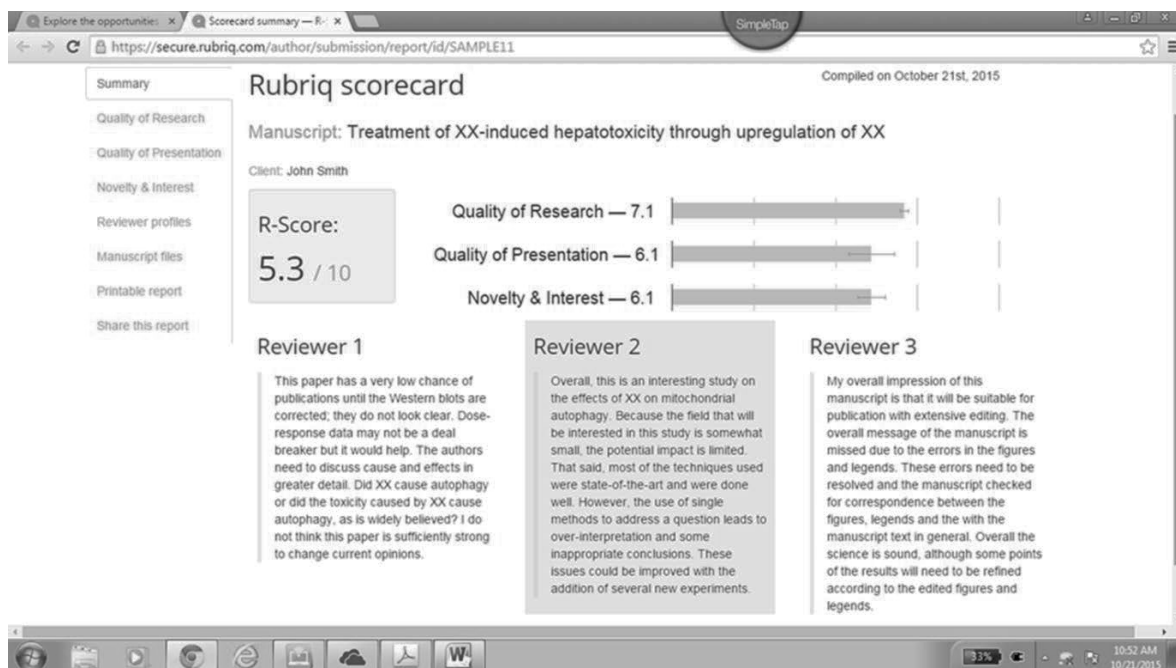


Figure 5: Rubriq, an online pre-submission peer review service

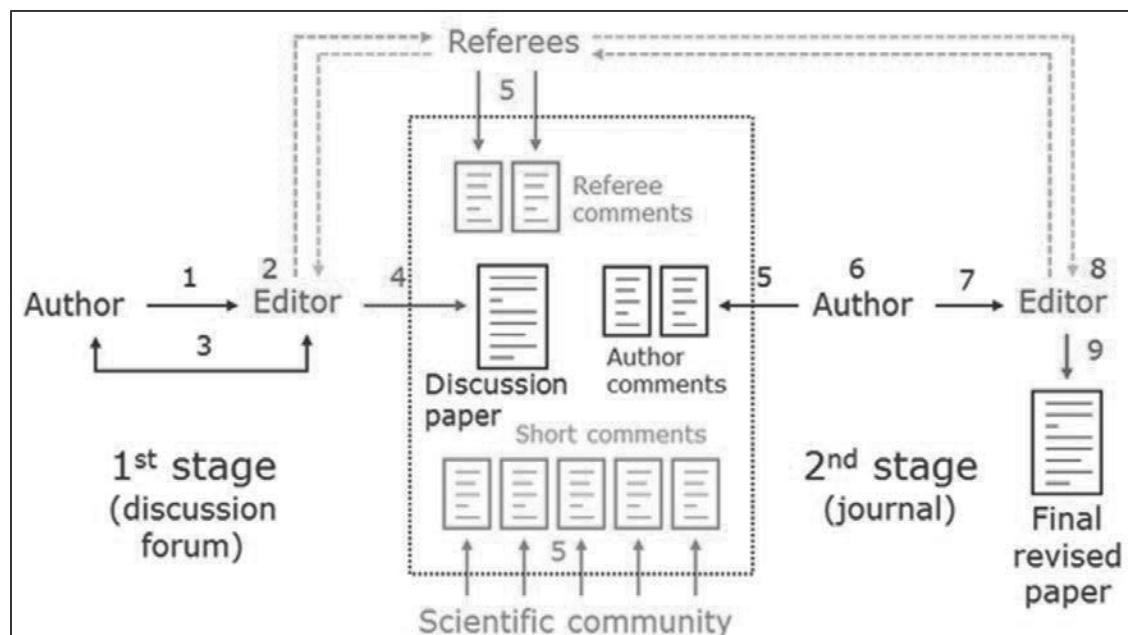


Figure 6: Journal of Atmospheric Chemistry and Physics Review Cycle

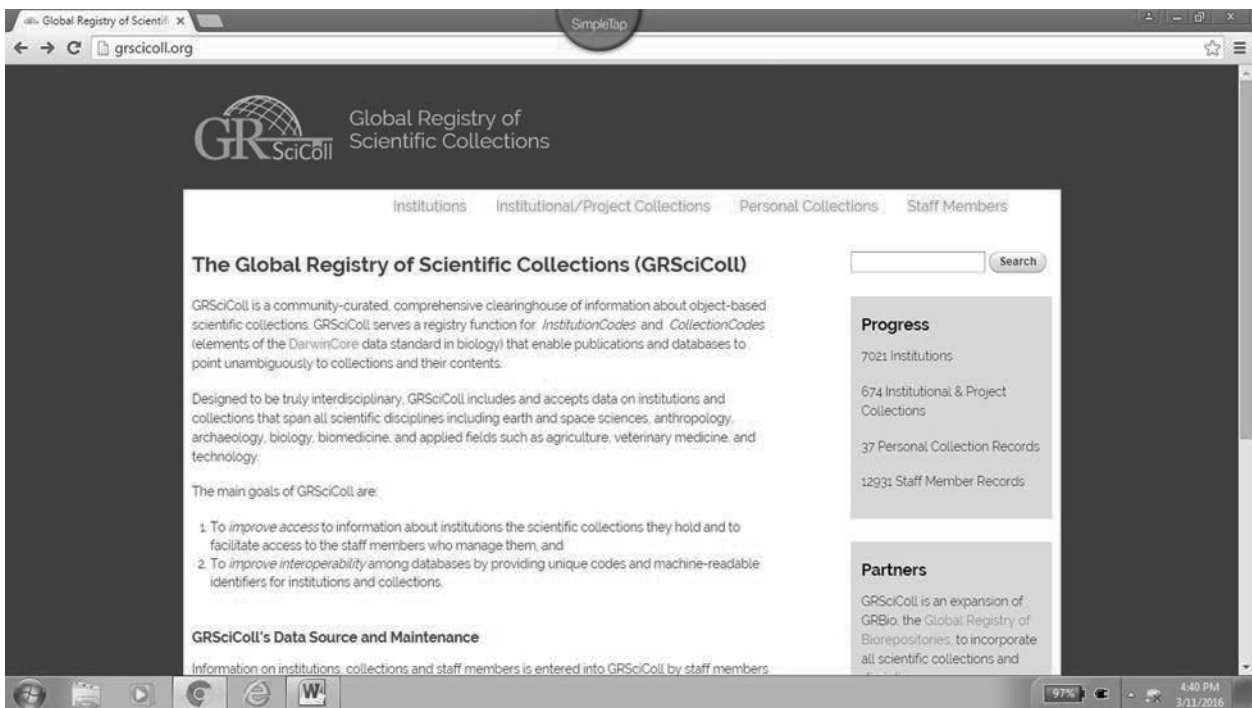


Figure 7: GRSciColl: The Global Registry of Scientific Collections. An online registry attempting to uniquely identify all scientific collections held in universities, museums or other repositories.

References

- Barker, Alex W.,
2010 Exhibiting Archaeology: Archaeology in Museums. *Annual Review of Anthropology* 39:293-308.
- 2001 Core Databases; Anthropology in Museums. *International Encyclopedia of the Social and Behavioral Sciences*, Neil J. Smelser and Paul B. Baltes, eds.,. Oxford: Elsevier Science, Ltd.
- Bearman, David
2008 Representing museum knowledge. In *Museum Informatics: People, Information, and Technology in Museums*, P. Marty and K. Jones, eds. New York/London : Routledge.
- Björk, Bo-Christer, Annikki Roos, and Mari Lauri
2009 Scientific journal publishing: yearly volume and open access availability. *Information Research* 14(1)(paper 391)(<http://InformationR.net/ir/14-1/paper391.htm>) (accessed 9/5/2016)
- Blumenstyk, Goldie
2016 Elsevier's New Patent for Online Peer Review Throws a Scare Into Open-Source Advocates. The Chronicle of Higher Education, http://www.chronicle.com/article/Elsevier-s-New-Patent-for/237656?cid=wc&utm_source=wc&utm_medium=en&elqTrackId=f4aabfe396fd47faa64097569f84c042&elq=198031dfb0304e56b8b2cd77d157fab9&elqaid=10545&elqat=1&elqCampaignId=3974 (accessed 9/6/2016).
- Bornmann, Lutz, and Rüdiger Mutz
2015 Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. *Journal of the Association for Information Science and Technology* 66(11):2215-2222.
- Childs, S. Terry
1995 The Curation Crisis. *Federal Archaeology* 7(4):11-15.
- Dempsey, Lorcan
2000 Scientific, Industrial, and Cultural Heritage: A Shared Approach. A research framework for digital libraries, museums and archives . *Ariadne* no. 22. <http://www.ariadne.ac.uk/issue22/dempsey/> (accessed 9/5/2016)
- European Bureau of Library, Information and Documentation Associations
2009 Digital Agenda for Europe: Digital Libraries Initiative. <http://www.eblida.org/news/digital-agenda-for-europe-digital-libraries-initiative.html> (Accessed 9/5/2016).

- Office of Science and Technology Policy (OSTP)
- 2013 Increasing Access to the Results of Federally Funded Scientific Research. Memorandum for the heads of executive departments and agencies from John P. Holdren, Director and Advisor to the President, 22 February 2013. https://www.whitehouse.gov/sites/default/files/micro-sites/ostp/ostp_public_access_memo_2013.pdf (accessed 9/6/2016)
- Price, Derek de Solla
- 1965 Networks of scientific papers. *Science*, 149(3683), 510-515.
- Riviera, E.,
- 2013 Scientific communities as autopoietic systems: The reproductive function of citations. *Journal of the American Society for Information Science and Technology*, 64(7), 1442-1453.
- Trant, Jennifer
- 2009 Emerging Convergence? Thoughts on Museums, Archives, Libraries and Professional Training. *Museum Management and Curatorship* 24(4):369-387.
- U.K. Parliament, Select Committee on Science and Technology
- 2004 *Scientific publications: free for all? Tenth Report of Session 2003-04. Volume 2. Oral and written evidence. Appendix 46. Memorandum from Reed Elsevier. London: Parliament.*
- van Raan, A.F.J.,
- 2000 On growth, ageing, and fractal differentiation of science. *Scientometrics* 47(2):347-362.
- Vann Sarah K.,
- 1961 *Training for Librarianship Before 1923. Chicago: American Library Association.*

Child Trauma Research: Future Directions and Next Steps

Yo Jackson, Ph.D., ABPP, Professor and Senior Scientist, Clinical Child Psychology Program/Life Span Institute, University of Kansas

Research on youth exposure to trauma is most often directed toward the study of the rate, nature, and outcome of experiencing atypical events during development. Although what is considered atypical can vary, for the most part, researchers have focused their investigations on experiences like exposure to child maltreatment, parental psychopathology, parental incarceration, parental substance abuse, chronic physical illness, natural disasters/war, exposure to crime, and poverty. The result of this work in its simplest form, suggests two abiding findings: 1) the majority of youth are exposed to one or more trauma experiences during their development, and 2) exposure poses significant risk for maladjustment, yet not all youth exposed to trauma develop pathology. Recognizing trauma's variable impact on youth functioning and the process by which trauma exposure comes to exert that impact is critical to understanding youth well-being.

Current statistics on the rates of youth exposure to trauma suggest rather staggering numbers. The approach to cataloging the rates of exposure has been twofold. One, assessment of the experiences of youth in the general population, and two, assessment of youth trauma who are known to systems of care (i.e., clinical samples, youth in juvenile detention, youth in foster care, youth enrolled in state-funded relief programs). Although considered nonnormative or atypical events, in that they are not an expected part of childhood, large-scale studies indicate that in community samples, 40-70% of over 11,000 youth sampled report exposure to at least one trauma (Finklehor, Ormrod, & Turner, 2009) before the age of 18. For clinical samples, or youth who have contact with mental health professionals and are receiving treatment, 78% report exposure to poly-victimization (Jackson, et al.,

2016) or exposure to more than one traumatic event. For samples of youth involved with systems of care, recent evidence suggests that 89% of youth who have contact with the juvenile justice system for example, have a history of poly-victimization (Pane-Seifert, et al., 2016). The data regarding the impact of exposure on mental, behavioral, and physical health is also fairly staggering with the most compelling evidence coming from studies like the Adverse Childhood Experiences Survey (ACES, Felitti et al., 1998). ACES, a study of over 9,000 adults indicated that exposure to trauma during childhood has a dose-response relation, meaning that for every one additional trauma experienced, the risk for a range of negative health outcomes increased. Individuals who had, for example, four or more categories of childhood exposure, compared to those who had experienced none, had 4- to 12-fold increased health risks for alcoholism, drug abuse,

depression, and a suicide attempt as adults.

The Felitti study was a landmark for the field and for most part, research continues to document the relation between exposure and outcomes, with most efforts either expanding the kinds of trauma assessed across different kinds, or documenting the range of maladaptive outcomes believed to be related to early exposure. The relation between exposure to trauma in childhood and negative health outcomes is not, however, automatic and the study of resilience seeks to determine under what conditions do youth exposed to trauma progress typically and demonstrate expected developmental milestones across social, academic, physical, emotional, and behavioral health domains. The focus on resilience in youth has taken many forms over the years, progressing from small sample, cross-sectional studies to large-scale efforts that follow youth and their development over time. One such example of the latter is the SPARK project.

SPARK project.

The SPARK project – Studying Pathways to Adjustment and Resilience in Kids, is a 5-year, longitudinal study funded by the National Institutes of Health. The goal of the project was to provide first-time evidence of how characteristics of the trauma, the youth, and the youth's environment interacted to predict well-being across a number of outcomes. The project was based on over five pilot studies that helped determine and confirm the potential role of several possible protective factors for youth exposed to trauma (i.e., resources). Specifically, the project tested how constructs known as resources such as intelligence, internal

locus of control, social support, family environment, and context of the traumatic event (i.e., events between family members, events at school) operated to moderate the relation between exposure and adjustment and how one's appraisal or interpretation and one's coping style operated to mediate outcomes for youth exposed to trauma (see Figure 1). To ensure that the sample was exposed to significant trauma and to perhaps document the process for youth perhaps at the greatest risk for later pathology, the sample was composed entirely of youth in foster care who had a confirmed history of child abuse among many other traumatic events.

It is important to note, resilience is a process and is really not served well by cross-sectional study designs. Moreover, to test for resilience, research has to include multiple outcomes. It is not enough to show that some youth exposed to trauma are doing well in school, or have low levels of pathology, but instead to truly test resilience, one has to show reasonable functioning across a range of domains of functioning. To that end, the SPARK project assessed the mental, social, behavioral, emotional, and physical health, and academic functioning (grades and behavior in class) over time and across three-month time points. In keeping with methodological traditions in child psychology, multiple reporters are also required and the SPARK project included both youth and caregiver-report as well as teacher-report of the youths' functioning. The youth participants were ages 8-21 and all of the youth were in the custody of the state social service agency. Each youth had been in foster care at least 30 days in their current placement and

we included youth in both traditional foster homes and residential care (i.e., 2-parent families and large facilities designed to house large numbers of youth).

Recruitment.

To access youth in foster care for research, the SPARK staff had to create working relationships with a myriad of stakeholders. Social service agencies are tasked with the protection of youth in foster care, even from well-intentioned researchers and thus it was important to ensure that the SPARK staff learned the culture of social services and modeled their expectations for cooperation accordingly. Specifically, it was important for the SPARK project to be useful for the State's mission in regard to youth in care, to add value to the process of protecting youth in care and to show how collecting data on the youths' well-being, including their history of abuse would be helpful to social services workers who interacted with youth and families daily. Moreover, the SPARK project required not only that the State provide access to youth in foster care (i.e., disclosing their names and foster parent contact information), but also give a copy to the SPARK staff of each child's case file or the legal documentation of each child's maltreatment history. Up until the SPARK project began, the state of Missouri had never granted access to the legal case file to an outside organization. To do so would require a great deal of trust on the part of the state of Missouri and a great deal of planning and care regarding the retrieval and storage of the documents. Case files include names of victims and perpetrators and specific details regarding the child's abuse history and for some youth, the in-

formation in their case file amounts to evidence used in court proceedings, medical findings, and police reports; information whose access is managed by legal statute. The SPARK staff met with the director of the Division of Social Services for the State of Missouri as well as the director of the Children's Division in Jackson County, Missouri to develop a plan for accessing youth in care as well as their case files. The State had to individually consent for each of the over 500 youth in foster care that ultimately became participants in the SPARK project, photocopy over 5,000 documents from the case files of these youth, and provide up-to-date contact information for the current placement of each child (placements that changed somewhat frequently over the course of the project). The SPARK project staff also met with and developed relationships with case workers, circuit court judges, court-appointed special advocates, and foster parent associations to ensure the success of the project. Needless to say, the process was time and labor intensive.

The SPARK project also collected data from each youth's teacher via an online survey. Great care was required to ensure that with youth often shifting home placements, that the information on the youth's current school and teacher was correct. Moreover, youth in project attended schools in over 27 different school districts, requiring permission from each district and each relevant school in a given district. Grades for each youth are not kept in a central location, nor are teachers available year round, thus it was no small undertaking for the SPARK staff to coordinate finding grade

cards and teachers throughout the project.

Data collection.

Once youth and foster parents were located, informed about the study, and agreed to participate, the process of data collection began. The SPARK project collected data from the youth and foster parents on over 2,000 variables, requiring a three-hour data collection session. Data was collected with the use of the Audio Computer Assisted Self-Interview (ACASI) where items from questionnaires are provided on the screen of a laptop computer, read aloud to the respondent over headphones and responses are stored on the computer hard drive. It was important to ensure the well-being of the participants during the project so the staff worked to provide breaks, games, snacks and support for the participants during the data collection sessions. Child care was provided for any other youth in the family and locations for data collection were chosen based on close proximity to the foster parent's home to ensure greater ease of participation in the project. A three-part debriefing after data collection was completed and all youth were contacted 48 hours after data collection to safeguard against any negative effects of participating in the project.

Preliminary results.

Data collection for the SPARK project ended in 2015 and thus far, the staff have disseminated results in over 10 published studies and over 15 conference presentations. Although the test of the "big model" is still in progress, there are a few preliminary results that may be of interest. One, youth who demonstrate adaptive functioning (expected progress physically, mentally, emotionally) do not have

less exposure to trauma than those who fare poorly, nor are they better copers or more intelligent or have more social support. What is characteristic of youth who are faring well is that they tend to have average intelligence, have more teacher support than any other kinds of support, tend to interpret events in a balanced way (see trauma events as both good and bad), and they tend to cope with trauma by directly addressing the problem. Two, those who do fare poorly across a range of developmental outcomes tend to have more family support than any other kind, see their families of origin as supportive and cohesive, tend to interpret trauma in a rigid manner (i.e., events are either all good or all bad), and they tend to cope with trauma by either avoiding it or by enlisting the help of others. It is possible that seeking others in times of stress is a good thing, however, for youth in foster care, often the "others" that are available are not adequate problem solvers to be effective in the lives of their children.

What universities can do to help?

Before federal funding was granted, the mentoring I received was invaluable. Having other investigators available and willing to discuss the application process was critical to my success. After I received the first RO1 grant, having release time to build infrastructure for the project and providing me with assistance in areas where I had little prior experience (i.e., budgets, hiring staff) was especially helpful in ensuring the success of the project. Projects like SPARK are not possible without significant support from the university infrastructure for research administration system and centers like the Life Span Institute at the University of Kansas. The university and the research staff

serve as a repository for what works in making large-scale research a reality and a training center for people to have vision for making impactful change in the lives of youth. The university has the capacity to assist investigators in building the systems (i.e., HIPPA compliant servers) that meet the needs of any project, like SPARK, where the most confidential, legal information can be easily stored, accessed and protected. This is not just a comfort to investigators, but a necessary element of any research institution that hopes to garner the trust of community and state agencies who provide direct access to special populations of youth.

The role of community-based research at universities has garnered greater and greater attention in higher education and in the wider public press. Research universities are under pressure to show their positive influence in the local community and the “stories” of university success in impacting change for the state and its residents become more and more what draws students to attend a given school. Early experiences in college can be important in laying the foundation for the development of the passion and energy that is required to effect change in the lives of youth over the long-term. University administrators may do well to expand their definitions of faculty productivity and student success to include activities that provide opportunities for students to get involved in projects that serve the broader community improvement. Education would come to mean then that students get something and give something back as the natural order of things in higher education. The important question for the future may be how universities can work to build the

kind of community relationships that are necessary to create large-scale projects that facilitate learning and community good.

Unfortunately and fairly often, the university is viewed by community and state agencies as not relevant to the mission of helping others, but it does not have to be this way. One exception is the recent work my lab has done at The Children’s Place (TCP), a community mental health center in Kansas City, MO. TCP serves the mental health needs of over 200 preschool-age youth and their families who have a history of child maltreatment. Working in partnership with KU, we created a practicum where graduate and undergraduate students work to assess treatment outcomes at the agency. With our data, TCP has been able to show local foundations how investment in their programming is effective for promoting youth adjustment, resulting in now four years of funding for several graduate students, and a data collection system that is now an integral part of their intake and discharge process. As a long-term result, TCP has changed some of their approaches to treatment, which for their clients, has led to less time in foster care, better parent-child relationships, improved youth mental health, and earlier readiness for preschool. The students learned real-world application of data collection techniques that actually serve a local agency that up until recently collected almost no information on their clients and their treatment outcomes. On a personal note, the success of the project has meant that I have been asked to speak to the Board of two of the primary mental health funders in Kansas City, MO about data collection processes and have been

asked to consult on another treatment evaluation program at another treatment facility for youth in the local area. It seems once community agencies understand that the university can provide support and a shared vision of improving services for youth, other agencies are sure to follow.

Future directions.

For supporting individual investigators, several suggestions seem relatively clear. One, it is important for universities to develop a culture of understanding of the heterogeneity of faculty within a given department. Some faculty members will never need grant funding to do good work, but some will, and even for those that do not need grants, it is possible that they could do even greater things if grant support was available. For those who seek grants, it is also important to identify a grant mentor, someone not necessarily in the same discipline, but who has the experience and time to provide regular support and guidance in navigating the ever-changing world of external funding systems. The peer review system at KU (where grant applications are sent to paid external reviewers) is a good start, but not likely sufficient for new investigators to learn what they need to know to be successful funded investigator.

Moreover, there is a sense that some new investigators have (in some ways due to bad advice from universities administrators) that getting grants has a lot to do with luck, funding climate or simply having the fortune of employing several self-driven passionate, researchers at a given university. It is possible that chance is at play, but it makes much more sense for universities to be proactive and

work to grow these “lucky” people. Although it is not clear if it is possible, but it would be a good idea to try to be systematic about the process, provide release time for writing grants, education about the application process, identifying funding mechanisms, and assisting faculty in building interdisciplinary teams who may have a better chance of addressing complicated research questions that can have significant application to the broader community.

It is also possible that for research administrators, it is time to rethink their role in the large-scale grant process. At most of the research meetings I hold with community organizations, especially when medical centers are involved, I find most medical administrators will make time to be present. That is, administration on the community-side of research is often very interested in participating in the research development process, but I cannot say I have found too many university administrators who see a role for themselves at these meetings. Perhaps investigators need to be more proactive as well and invite research administrators to community meetings so they can see first-hand how important their interest is to the motivation of others (investigators and community members alike) to be a part of a project.

Besides educating students, universities have to want to be known for addressing some type of problem. Much like the study of resilience in youth, most intractable social problems are complicated and multi-determined. Child maltreatment, for example is non-linear, as it does not have a one-to-one cause and effect that is easily identified. As a result, children exposed to child maltreatment

may end up with some or many or no mental health problems later in life. It is unlikely that any one lab will determine under what circumstances youth will end up in the some or many or no mental health problem pathway, thus the need to collaborate across labs and institutions is vital to untangling the effects of trauma.

Exposure to trauma is one of many “wicked problems” universities across the country are committed to addressing and it is important for everyone’s future success that universities see their important role in promoting success and manifesting change for the community.

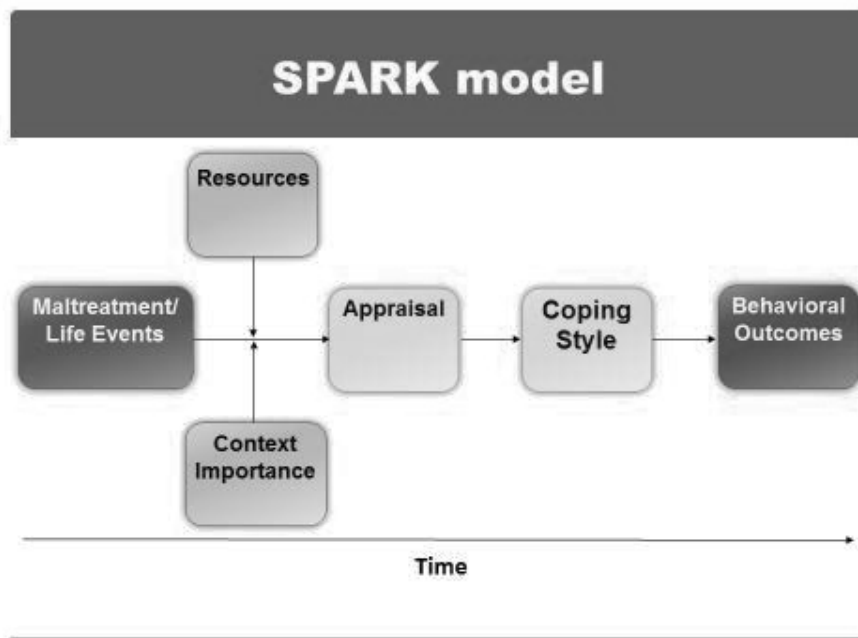


Figure 1: SPARK Model of resilience in youth exposed to trauma

References

1. Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., Koss, M. P., & Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. *American Journal of Prevention Medicine, 14*(4), 245-58.
2. Finkelhor, D., Ormrod, R.K., and Turner, H.A. (2009). Lifetime assessment of poly-victimization in a national sample of children and youth. *Child Abuse & Neglect, 33*, 403–411.
3. Jackson, Y., Cushing, C. C., Gabrielli, J., Fleming, K., O'Connor, B. M., & Huffhines, L. (2016). Child maltreatment, trauma, and physical health outcomes: The role of abuse type and placement moves on health conditions and service use for youth in foster care. *Journal of Pediatric Psychology, 41*(1), 28-36.
4. Pane-Seifert, H. T., Tunno, A. M., Briggs-King, E. C., Lee, R. C., Grasso, D. J., Adams, Z. W., & Ford, J. D. (2016, July). Poly-victimization and psychosocial outcomes among juvenile justice youth: Implications for trauma informed systems of care. Panel presentation presented at the 2016 International Family Violence and Child Victimization Research Conference, Portsmouth, NH.

Technology and Research

Hannes Devos, PhD

Assistant Professor

Department of Physical Therapy and Rehabilitation Science, School of Health Professions

University of Kansas Medical Center

Abiodun Akinwuntan, PhD, MPH, MBA

Dean and Professor, School of Health Professions

University of Kansas Medical Center

Technology is a word that is frequently used in scientific circles but with no simple definition. It is such a complex word that it has been described to encompass three meanings: tools and instruments; culture; and knowledge.¹ In the desire to cope with the natural demands of human existence, tools and instruments are developed to solve a variety of problems. These problems, which include but are not limited to transportation, housing, clothing, food cultivation and preservation, nutrition, communication, leisure, entertainment, and health care, are largely driven by human culture. Although the use of technology in changing the world and our immediate environment started around the mid-1700s to 1800s, the current wave of advances in technology really picked up in the mid-1940s. The significant increase in technological advancements around this period was predominantly driven by the advent of computers, new information and communication technologies, and the internet.

The creation of tools and instruments are encoded and passed on from one generation to the other as technological knowledge. For accurate transmission of technological knowledge, research was needed. Research is the systematic investigation and collection of information to establish facts, confirm existing knowledge, or develop new knowledge on any subject matter. As such, empirical observation methods, hypotheses, and inferences on laws concerning behavior of materials and environmental conditions were developed. The effective transmission of knowledge has led to significant advancements in technology,

which has continued to revolutionize virtually every aspect of the world we live in today.

The automobile industry is a great example of how technology changed the world. The history of automobiles dates as far back as the 18th century. Since that time, the automobile industry has gone through several technological advancements from steam-powered vehicles, to internal combustion engines, and now electric automobiles. In the early 20th century, Henry Ford introduced the Model T, which was simple and light, yet sturdy enough to drive on the country's primitive roads. The mass production of this automobile lowered its unit price, making it affordable for the middle class, and

transformed the road network into the driving landscape as we know it.

In the highly motorized world that we live in today, driving has become a primary necessity to the extent that it is regarded as an instrumental activity of daily living. However, driving today is also a highly risky activity with very significant safety implications. The ability to react accurately and promptly to highly time-dependent events is a major requirement to drive safely on public roads. The sequelae of many medical conditions, especially those that affect the nervous and visual systems of the human body, negatively affect the ability to drive.²⁻⁷ Examples of medical conditions that affect the nervous system include stroke,² multiple sclerosis,³ Parkinson's disease,⁴ Alzheimer's disease,⁵ and traumatic brain injury.⁶ Macular degeneration, glaucoma, and retinopathies are some examples of medical conditions that affect the visual system.⁷ The focus of many research endeavors has been to develop the most efficient methods of assessing fitness-to-drive of individuals who have experienced any medical condition that has an impact on the ability to drive.^{8,9} Furthermore, some research activities have been directed at developing intervention programs that can be used to retrain driving performance after a medical condition. Until very early in the 1980s, assessment and retraining of fitness-to-drive after a medical condition have taken place in real vehicles, on real roads, and in real-life traffic situations. Not only are these practices unsafe, adverse conditions needed to adequately test hazard perception and avoidance skills of the individuals are not guaranteed to happen and are usually avoided, also for safety reasons.

The potential risk of accidents, the lack of standardization and reliability of on-road tests, and the costs associated with on-road driving tests, urged researchers and clinicians to look for safer, cheaper, and more effective technological alternatives to on-road testing.

Driving Simulators

Driving simulators offer a unique opportunity to conduct fitness-to-drive assessments and interventions in a safe environment. The use of driving simulators for these purposes started about the middle of the 20th century. The driving simulators at that time were primitive and had limited meaningful application in assessing and retraining the full spectrum of skills involved in on-road driving. The early simulators were used predominantly to evaluate the ability of the driver to appropriately control the steering wheel, operate the gas and brake pedals, accurately position the vehicle on the correct road lane, and make simple turns, but without other vehicles on the road.¹⁰ Performance during more complex driving activities such as driving within the speed limit, overtaking other cars, driving through busy intersections, and making left turns against oncoming traffic could not be assessed nor retrained in the early simulators. However, technological advancements have led to the development of high fidelity virtual reality driving simulators in which the more complex driving activities as well as the simple ones can be assessed and retrained with a high degree of ecological accuracy.¹¹ Simulator-based assessment and intervention now offer researchers and driving assessment experts the opportunity to evaluate and retrain driving be-

haviors in near-realistic driving situations that elicit natural reaction to such situations. For example, a driver's response to a potentially dangerous maneuver by another driver or driving performance during adverse weather or lighting conditions can be readily evaluated in current driving simulators. The fact that the simulated drives are performed without the risk inherent in real-life driving situations and can be recorded and replayed at a future time enhance the utility of driving simulators as innovative tools for evaluating and retraining driving performance, especially in persons with medical conditions.

In various studies, we established the usefulness of a driving simulator to retrain impaired driving skills after different medical conditions including stroke, multiple sclerosis, and Parkinson's disease.¹¹⁻¹⁴ In the stroke study, a total of 83 participants between six and nine weeks after the onset of a first-ever stroke were recruited into a randomized controlled trial.¹¹ Forty-two of them were randomly allocated to an experimental group that received 15 hours of structured training in a high fidelity driving simulator. All simulator scenarios were specifically created for this study and tailored to the needs of each individual driver. The other 41 participants were allocated to a control group that received 15 hours of structured cognitive rehabilitation using off-the-shelf puzzle games. In both groups, the 15 hours of training, which took place in one hour sessions, three times a week over five weeks, was in addition to standard rehabilitation. Before commencement and immediately after training, all participants performed a

comprehensive fitness-to-drive evaluation that included assessments of visual, cognitive, and practical on-road driving skills. Performance on the same tests that were conducted as part of an official state-mandated fitness-to-drive evaluation at about six months after stroke onset was also documented. The study results showed improvements on the visual, cognitive, and on-road tests immediately after training in both groups and the benefit in the experimental group was superior. At the six-month evaluation, significantly ($p = 0.03$) more participants in the experimental group (73%) in comparison to the control group (42%) passed the fitness-to-drive after evaluation and were legally allowed to resume driving. In a long-term follow-up study that was conducted at about five years after the stroke, 60% of the 30 experimental group participants in comparison to 48% of the 31 controls again passed the official state-mandated fitness-to-drive evaluation.¹² Similar benefits of using the high fidelity driving simulator to improve performance of driving-related skills were observed in others studies that we conducted that included individuals with relapsing remitting multiple sclerosis¹³ and persons with mild to moderate physical disabilities due to Parkinson's disease.¹⁴

Although the interest in driving simulation technology is growing, clinicians are still apprehensive of using simulators to evaluate and train driving skills of patients with medical conditions. Concerted efforts should be made by researchers and software manufacturers to facilitate the transition of research technology to practical implementation in the clinical community. Examples include creating user-friendly interfaces to ease

the operation of the simulator, providing summary print-outs of the data that can easily be interpreted, and demonstrating the validity of simulation technology to real-world driving performance.

Future Plan

In future studies, we plan to look at the benefits of measuring cognitive workload while performing different cognitive tasks of varying levels of difficulty in the driving simulator. Cognitive workload is defined as the mental effort needed to execute a task.¹⁵ For decades, the only established methods of measuring cognitive workload were positron emission tomography or functional magnetic resonance imaging. These neuro-imaging measures were sometimes intrusive and required subjects to lie still in a scanner while taking pictures of the brain. Consequently, these scanning techniques are not optimal to study complex cognitive tasks while driving. Recent advancements in technology showed that other measures, including electroencephalography or magneto-encephalography, functional near-infrared spectroscopy, cardiovascular measures (blood pressure), electrodermal measures, and pupillometry (changes in pupil size), can be used outside the scanner to assess cognitive workload.¹⁵ In our future studies, we will use pupillometry that is evoked by specific cognitive tasks with established levels of complexities because it accurately reflects fluctuations in cognitive activity over the entire time of engaging in the task. Task-evoked pupillary response (TEPR) is an involuntary reflex, caused by a decrease in parasympathetic activity in the peripheral nervous system as a result of increased cognitive workload.¹⁶ Our main hypothesis, based on findings in other

studies, is that the known differences in cognitive workload between individuals with diagnosed progressive neurological conditions when compared to healthy individuals matched for age and education will be more accurately detected using pupillary size changes. Accurate detection of abnormal changes in cognitive workload may be a precursor and earliest indicator of cognitive decline in progressive neurological conditions. Early detection of cognitive decline will inform targeted interventions capable of slowing down the rate of disease progression thereby prolonging highest quality of life. It is our hope that as our studies develop further, we will attract the right partnership within the industry to develop innovative products that are very sensitive in detecting earliest onset of cognitive decline and offer the possibility of earlier introduction of effective interventions.

Advocacy for Collaborative Research

For advancements to continue to have meaningful and translational impacts on all the aspects of human activities that are technology-influenced, transmission of technological knowledge to healthcare and industry will need to be more effective and accurate. More randomized controlled trials and long term follow up studies are needed to ensure proper transmission of advancements in technology. Such trials should include reliable and valid measures to enable reproducibility and generalization from one research location to another. Associated with the increasing complexities of technology, is the issue of new forms and huge amounts of data generated by the technologies. Data mining and management are therefore important skills to

possess or procure in conducting research around current technology. Fortunately, advancements in computer technology have made effective handling, storage, and accurate analyses of humongous quantitative and qualitative data possible. Knowledge gained from technologically-based research, like any other research, should be comprehensively documented, disseminated widely, and published in peer-reviewed journals in order to add to the body of knowledge.

To keep the vehicle of technological advancements going, it is important for universities and the industry to continue to engage in scientific partnerships. For a successful university-industry partnership, not only is the support and belief of the leadership of both organizations in

the partnership crucial, it needs to be a top priority. The appropriate manpower, resources, and incentives needed to ensure the success of the partnership need to be available in both organizations. Such partnerships should not be bogged down by the bureaucracies and selfish interests of both organizations. As such, it is important for a detailed memorandum of understanding that clearly establishes all the terms of agreement to ensure effective communication and clearly defined expectations between the parties in the partnership to be developed. According to Edmondson et al, 2012, when such partnerships work well, they merge the discovery-driven culture of the university with the innovation-driven environment of companies.¹⁷

References

1. Vergragt PJ. How technology could contribute to a sustainable world. Tellus Institute 2006. 1-29.
2. Devos H, Akinwuntan AE, Nieuwboer A, Truijen S, De Weerd W. A systematic review and meta-analysis on predictors of fitness to drive after stroke. *Neurology* 2011; 76(8): 747-56.
3. Lincoln NB, Radford KA. Cognitive abilities as predictors of safety to drive in people with multiple sclerosis: *Multiple Sclerosis* 2008; 14(1): 123-128.
4. Devos H, Vandenberghe W, Nieuwboer A, Tant M, Baten G, De Weerd W. Predictors of fitness to drive in people with Parkinson disease. *Neurology* 2007; 69 (14): 1434-41.
5. Ranchet M, Tant M, Akinwuntan AE, Morgan JC, Devos H. Fitness-to-drive disagreements in individuals with dementia. *The Gerontologist* 2016, August 5 (Epub ahead of print).
6. Schultheis MT, Whipple E. Driving after traumatic brain injury: evaluation and rehabilitation interventions. *Current Physical Medicine and Rehabilitation Reports* 2014; 2(3): 176-183.
7. Klein R. Age-related eye disease, visual impairment, and driving in the elderly. *Human Factors* 1991; 33(5): 521-525.
8. Devos H, Ranchet M, Akinwuntan AE, Uc EY. Establishing an evidence-based framework for driving rehabilitation in Parkinson's disease: a systematic review of on-road studies.

- NeuroRehabilitation 2015; 37(1): 35-52.
9. Devos H, Akinwuntan AE, Gélinas I, George S, Nieuwboer A, Verheyden G. Shifting up a gear: considerations on assessment and rehabilitation of driving in neurological conditions. *Physiotherapy Research International* 2012. 2012; 17(3): 125-31.
 10. Kent H, Sheridan J, Wasko E, June C. A driver training program for the disabled. *Archives of Physical Medicine and Rehabilitation* 1979; 60: 273-276.
 11. Akinwuntan AE, De Weerd W, Feys H, Baten G, Arno P, Strypstein E, Kiekens C. Effect of simulator training on the driving ability of stroke patients: a randomized controlled trial (RCT). *Neurology* 2005; 65: 843-850.
 12. Devos H, Akinwuntan AE, Nieuwboer A, Tant M, Truijien S, De Wit L, Kiekens C, De Weerd W. Effect of simulator training on driving after stroke: a 5 year follow-up of a randomized trial. *Neurorehabilitation and Neural Repair* 2010; 24(9): 843-850.
 13. Akinwuntan AE, Devos H, Baker K, Hoogstra M, Phillips K, Kumar V, Smith S, Williams JM. Improvement of driving skills in persons with Relapsing Remitting Multiple Sclerosis: a pilot study. *Archives of Physical Medicine and Rehabilitation* 2014; 95(3): 531-537.
 14. Devos H, Morgan JC, Onyemaechi A, Bogle CA, Holton K, Kruse J, Sasser S, Akinwuntan AE. The use of a driving simulator to improve on-road driving performance and cognition in persons with Parkinson's disease: a pilot study. *Australian Occupational Therapy Journal* 2016, April 13 (Epub ahead of print).
 15. Ranchet M, Morgan JC, Akinwuntan AE, Devos H. Cognitive workload in healthy aging and age-related neurodegenerative diseases: A systematic review of physiological measures. In-Review.
 16. Beatty J. Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin*. 1982; 91: 276-292.
 17. Edmondson G, Valigra L, Kenward M, Hudson RL, Belfield H. Industry-University Partnerships Work: Lessons from successful collaborations. *Business Innovation Board AISBL of the Science*, 2012. 1-50.

Animal Research Support: The Transition from Ancillary Service to Contract Research Organization

Jerry Zamzow, Assistant Vice President for Research
Iowa State University

The use of animals in research is a vital component in the formula for advancing the human (and animal) condition. The use of animals in research is, at times, controversial. Engaging in these activities should not be taken lightly given the lightning rod that this work can be. Public perception and understanding has shifted over the past few decades, and institutions assume much responsibility, along with significant amounts of risk when working in the sphere as we strive to advance science and knowledge. Centralizing more of this responsibility and risk is a mechanism to ensure not only the regulatory aspects of this work are met to the fullest extent, but also can be used to mitigate questionable research practices and reduce bias.

Historical Aspects of Animal Research

Though animals are used in a wide array of disciplines, the greatest use has been in the life sciences sphere. Researchers have grown through systems that have a tradition of using animal models as part of their scientific inquiry. The majority of studies utilizing animals have historically been single investigator laboratories where the principal investigators provided much of the hands-on training for staff and students. Vivarium operations largely served to provide husbandry, medical care and appropriate space for the studies to be carried out. The regulations governing the use of animals in research and compliance thereof was comparatively manageable. A strong focus on animal welfare based on performance measures was the norm.

The Shift

As society expands its understanding of the world and biological systems associated with it, understandably, public perception of the use of animals in research has also shifted. The regulations

and guidance documents from governing agencies have responded to this shift as well; growing in sheer volume along with prescriptiveness in terms of engineering standards and the expectations that users of animal models are also versed in knowledge and application of the requirements. Along with written regulatory pressure, there has also been increased scrutiny from those agencies charged with upholding the regulations, along with voluntary accreditation bodies whose stamp of approval serve as a gold standard for robust animal care and use programs. That is not to say that this shift is a negative trend for animal research. I would posit that the shift is indeed a positive one in that it ensures that institutions and individual researchers are being deliberate in their approach to the matter. This trajectory, nonetheless, does pose greater risks for an institution that must be addressed and mitigated.

Along with the shift in compliance aspects, the science itself has shifted. The rise of interdisciplinary research has brought non-traditional animal users into

the space. Further, the studies that are being carried out are much more advanced in nature. Advances in in vitro and virtual realms have allowed for a reduction in the use of animals in preliminary work. This is a positive advancement, and rings true to the three paramount tenets of the use of animals in research: Reduce, Refine, and Replace-the "3Rs". With these advances also come challenges. As the traditional "feed them and weigh them" studies at agricultural schools are now more the exception rather than the rule, the procedures to be carried out in the models are much more advanced, intense, and prescript. This brings with it a need for greater inputs on training of researchers and their staff, along with advanced space, equipment and overall expertise.

What could a CRO look like?

To help researchers overcome what may be perceived as barriers to using animal models, an operational model that might be employed is for an institution's vivarium to function as a contract research organization (CRO) rather than an ancillary service. The vision would be that the vivarium functions as a "one stop shop" for investigators. The CRO would function like commercial CROs currently do by providing assistance in study design, animal use and standard operating procedure development, carrying out the activities, and subsequently returning the results to the investigative team.

What are the pros to this model?

Benefits to this model are potentially many. Institutional risk is mitigated by having highly trained staff being intimately involved with all aspects of a

study. Reducing protocol drift and adverse events that may occur due to human error associated with unfamiliarity of techniques and procedures might also increase the reliability in results and reduce unnecessary repetition of studies due to failures; again helping achieve the goals of the aforementioned "3Rs".

Research is an ever-changing and sometimes unpredictable endeavor, especially in biological systems. As the research unfolds, naturally investigators seek to follow the new path that they have been put on. At times, this may lead to questionable research practices that put the investigator and institution at risk. By managing the process in a controlled and unbiased environment, this fluidity can be managed to ensure that the studies are carried out with a greater confidence in regulatory and ethical integrity.

Functional and operation benefits include cost-savings to be realized for focused training efforts (i.e., a core group versus an entire institution), non-duplication of efforts and equipment, and less taxing of other systems (i.e., the IACUC). Additionally, institutions will likely garner a greater sense of confidence in their animal care and use program due to more controlled environments as the studies are carried out. Further, a more efficient use of space might be realized as the cyclical availability of researchers having students and staff to carry out the studies would be eliminated. Most importantly, principal investigator time savings will be realized through a reduction in administrative burdens and the actual time spent conducting the experiments.

What are the cons and changes needed?

As the duties of carrying out the animal studies shift to other parties, perhaps the greatest negatives to this model are the loss of a teaching opportunity and a sense of closeness to the work. Given the shift in types and disciplines that many animal studies are stemming from, the culture of animal use is not engrained, perhaps rendering this moot. Additionally, a negative would be the up-front financial costs associated with the model. Having sufficient personnel and associated expertise, along with the physical infrastructure related to equipment and space does not come without cost. While direct dollars spent may increase, the previously mentioned savings will likely offset this.

Changes needed to operationalize such a model most importantly include central support. An investment in the model would be needed to make it functional, with the realization that costs may not be recouped for some time. However, with proper changes to cost structures and fee schedules, such a program would likely become self-sustaining.

Perhaps the most significant change needed would be to the institution's human capital. While traditional animal caretakers will always be imperative to these operations, skilled individuals not only trained in functional technique, but also scientific processes will be needed to make the CRO successful. Providing a robust and continuous training program for these individuals is a lynchpin for success of the model. Failure to do so will likely result in the loss of the many benefits.

Conclusion

In sum, the model of a CRO is an opportunity for an institution and research offices to provide a greater level of service to today's investigators and their research. As researchers face many pressures and challenges, this is a mechanism to aid in minimizing those, while also assisting the institution in addressing the pressures and challenges it faces.

The Value added of Education at a Public Research University

**April C. Mason, Ph.D., Provost and Senior Vice President
Kansas State University**

The Carnegie classification system for universities is important. Kansas State University is a very high research public university. At conferences, administrators divide around this categorization. Ranking of these universities is monitored by growth in research dollars. Faculty are nominated for national awards by this category. Universities invest in startup packages to assist faculty with their research success, and success is monitored against metrics in strategic plans with research, creative activity, scholarship and discovery.

Universities also highly value student success. This factor is not added as an afterthought—faculty and staff at public research universities work to help students succeed. The intentional advising, technology to assist advisors, early warning programs, tutoring, learning communities, first year seminars—and many other programs, all are set up to assist students to be successful.

Recently, the Kansas legislature passed a law that Kansas public universities must make available the cost of education, the time to degree, and the salary a graduate can expect upon completion. The website development project was not without controversy, academic leaders were wary but the idea is sound if executed well. Students should know what they will invest and what type of return they can expect.

Each public research institution identifies peers against which they measure the progress on benchmarks of their strategic plans, all public research universities. Student enrollment professionals also identify a set of institutions, compet-

itive peers where students decide to attend for their education. These may not be anything like a public research university.

What factors lead to competitive schools for attendance? A few include cost, value of education, undergraduate research opportunities, scholarships, advising and time to degree completion. There are many others.

What does a public research institution provide in the value added of education that a non-research university does not or cannot? Public research universities can be expensive when compared to other means of education. Although the data is flawed in many cases, the new Kansas legislatively mandated website, does not show a happy picture for the return on investment of a degree from the research publics in the state compared to the comprehensive lower research universities.

Do students know research is being conducted at public research universities? Is the percent of students growing that participate in undergraduate re-

search? Do faculty bring their own research into the classroom to help inform? Do students see a difference? Even small private liberal arts college provide some level of undergraduate research. Do the faculty and staff of large public research powerhouses get students excited about research? Do they do this for a majority of their students?

This fall at the APLU meetings in Austin, Texas, this topic of value added of public research university education is going to a big topic. Large public research universities will not compete with the regional universities on price and continue to survive. The large public universities will need to compete with the regionals on value added. Value added is not the same as quality. Personally being a product of the small liberal arts college, I do not wish to impugn the quality of education at other institutions in Kansas and elsewhere, but it is critical to show the value added of the public research education. From the very beginning of a student's career, actually from the very first time a potential student reads material about the public research university, visits the campus, the value added of being a research intensive institution must be clear and evident.

It is critical the research superstars at a university are also in the classrooms, being teaching superstars. A great deal is asked of faculty. The alternative choices of education for today's students are so many. Mike Leavitt of Western Governors University describes WGU having over 70,000 graduates and 60,000 current students. The average time to degree is 2.5 years at a cost of \$6,000. WGU monitors a \$10,000 increase in salary for graduates. Public research universities cannot

compete with that, nor do they want to. But there will be students who need/want/have to have a WGU degree. What can be done to make the educational value of a degree from the public research universities mean more, value more, help more, and better prepare students?

My own two stepchildren attended Purdue University while I was a faculty member there. I am proud of the fact that one Christmas, Jeff wanted to get my father the book his history faculty member has just published on the Civil War. That faculty member told his class about his book—and that day Jeff was listening! Cleaning out my parents' home years later after they were gone, I came across the book, inscribed by the professor, because Jeff had asked him. Scholarship of the faculty member, shared in the classroom that touched a student. This is one of many stories that can be told.

Recently at a foundation trustees meeting at Kansas State University, a panel of students were asked to talk about their experiences at the University. A trustee, a local banker asked this question to the panel: if I gave you \$10 million dollars today what would you suggest be done with it for the university? The answers were truly amazing. One student indicated they would remodel the chemistry laboratories for research, another said they would increase stipends for graduate students, a third indicated they would help more students go on study abroad experiences.

Why do administrators stay in higher education administration? It is hard, the states continue to divest, there are more and more expectations, less money, and

the future does not look bright. However, the future does not look bright, if higher education stays the same. Higher education will have to be different. Administrators will have to clearly articulate what public research universities are and what they are not. Public research universities may have to be smaller, they may have to be substantially different, but they must show the value of what they are, why an education from a public research university is important and why the average undergraduate, state legislator, governor or parent should care.

Standing still is not an option. Being great at certain things and focusing on those things is essential. Strategic thinking, planning and action are more important than at any other time in the history of public research university education.

Assessing Research Productivity

Sara Thomas Rosen, Dean of Arts and Sciences
Georgia State University

Universities aspire to excellence in their classrooms, in their sports arenas, in their residence halls and cafeterias, and in the services they provide students. Research universities additionally aspire to excellence in research and scholarship. Research and scholarship aspirations create additional responsibilities for administrators: They must hire, develop, and encourage research-productive faculty; they must shore up weak departments and programs while preserving high-performing units; and they must lure top faculty from other institutions while defending their own research stars from well-funded poachers.

Whether research and scholarship at a university grow or shrink over time depends upon the decisions that administrators make. The best decisions are data-driven. Decisions aimed at increasing research and scholarship require large quantities of data, including data that extend beyond one's own institution. For example, administrators must compare their own institution with others in order to learn how often art history faculty ought to publish books, or to learn how many articles per year an organic chemistry laboratory should produce, or to learn which of their own faculty are nationally prominent.

Data summarizing faculty activity are available commercially although at a steep price. The cost-benefit ratio of purchasing access depends upon how well an institution uses the data. The present paper demonstrates the value of data about faculty activity by working through actual data from the University of Kansas, a public research university.

The University of Kansas (KU) is a member of the Association of American Universities (AAU), one of sixty-two public and private institutions in the U.S.

and Canada. AAU membership is awarded to universities that excel in research and scholarship as operationalized primarily by the following criteria:

- number of publications;¹
- number of citations;
- total grant dollars;
- number of national academy memberships.

The AAU's attention to citations reflects a core value: Research and scholarly activity ought to have an *impact*. Citation counts provide the most widely accepted measure of impact.

Operationally, a publication's citation count equals the number of other publications that cite it. A substantial literature discusses the pros and cons of citation counts and various weighted alternatives (e.g., the *g*-index² and one or another version of the *h*-index³). The present paper avoids the citation count controversy on the grounds that, at this time, no practical alternative exists to measuring impact through citations.

Publication counts (how many publications) and grants (how many grants and their dollar value) also measure what faculty are accomplishing. The present

paper treats four measures—citation counts, publication counts, number of grants, and grant dollars—as jointly illuminating faculty members’ research and scholarly contributions, or *faculty scholarly productivity*.

At the 2014 Merrill Retreat, Joseph Steinmetz discussed what The Ohio State University uses scholarly productivity data for: to compare OSU faculty with those of other institutions, to compare OSU departments and programs with those of peer institutions, to prepare program review evaluations at OSU, and to make decisions about where to invest OSU’s resources. The present paper extends Steinmetz’s recommendations by showing how to use productivity data to

identify factors that influence productivity.

Methods

Academic Analytics Dataset and Major Metrics

Academic Analytics furnishes counts and sums of book publications, journal publications, citations, grants, grant dollars, and conference talks.⁴ Counts and sums are difficult to compare across universities because they depend upon the size of a department or program. The Academic Analytics database therefore adjusts counts and sums by dividing by the number of faculty in a department. The present paper examined eleven measures. The measures examined are listed in Table 1.

Table 1: Measures of Research Productivity

Measure	Type of Measure	Collection Period
Percent of Faculty Who Published a Book	Percentage	2005-2014
Mean Number of Books Per Faculty Member	Ratio	2005-2014
Percent of Faculty Who Published a Journal Article	Percentage	2011-2014
Mean Number of Journal Articles per Faculty Member	Ratio	2011-2014
Percent of Faculty With a Citation	Percentage	2010-2014
Mean Number of Citations per Faculty Member	Ratio	2010-2014
Mean Number of Citations per Article	Ratio	2010-2014
Percent of Faculty Awarded a Grant	Percentage	2011-2014
Mean Number of Grants per Faculty Member	Ratio	2011-2014
Mean Grant Dollars per Faculty Member	Ratio	2011-2014
Mean Dollars per Grant	Ratio	2011-2014

At present, the database only collects citations of journal articles found within journal articles. The dataset does not yet collect citations of books or citations found within books.

Institutions

The present paper compared the University of Kansas to its peer institutions, some comparable and others aspirational. KU's peer institutions (as approved by the Kansas Board of Regents) are:

- Indiana University
- Michigan State University
- University at Buffalo
- University of Colorado – Boulder
- University of Florida
- University of Iowa
- University of Missouri – Columbia
- University of North Carolina – Chapel Hill
- University of Oregon
- University of Virginia

Although the database tracks the activity of individual faculty, data about a university's individual faculty are visible only to subscribers within that university. In the interest of preserving confidentiality, this paper avoided identifying individual faculty at KU. The paper also de-identified KU's peer institutions (KU is labeled "K" in the figures that follow).

Departments

Nine departments were selected for detailed analysis before examining any productivity data. Several criteria guided the selection. First, all nine departments are typically found within a college of (liberal) arts and sciences (as opposed to,

say, computer science, which often resides within schools of engineering). Second, departments had to have at least ten faculty members in each of the eleven institutions. Third, the selection process avoided departments that were heterogeneous across universities because of highly specialized subfields.

The next step was to prepare tables and graphs that summarized faculty productivity within all nine departments of all eleven institutions. Department-by-department examination of the results found three departments for which the results pointed to interesting patterns of productivity. Those three departments included one in the social-behavioral sciences (SS1), one in the natural-mathematical sciences (NS1), and one in the humanities (H1). The Results section begins by examining SS1, NS1, and H1 in depth, and concludes by summarizing the productivity of all nine departments.

Results

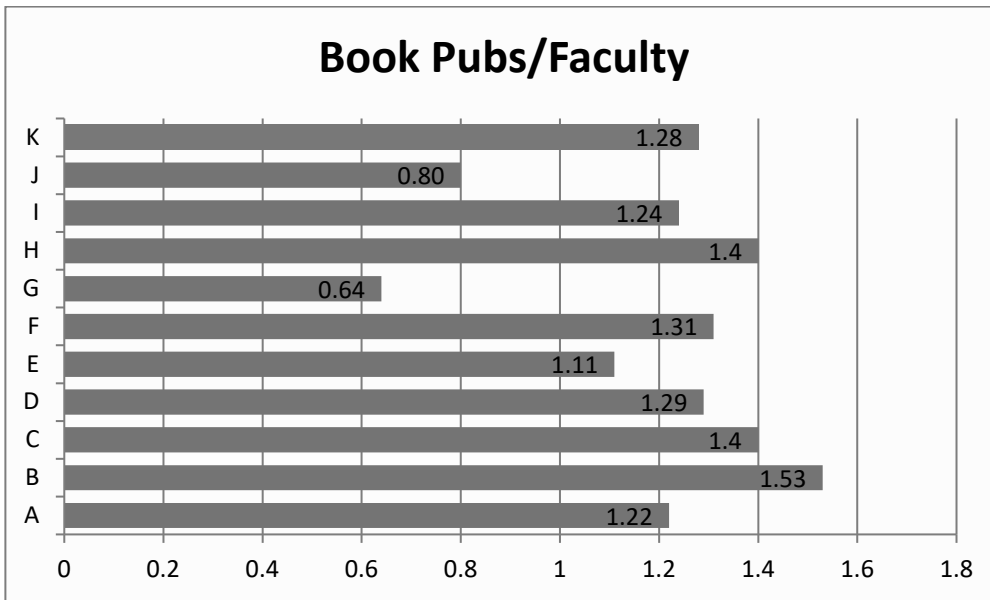
Social Science – SS1

As measured by the number of faculty, department SS1 is slightly small relative to KU's peer institutions.

Books

Sixty-seven percent (67%) of the KU's SS1 faculty published a book during the Academic Analytics data collection period, slightly higher than average for the peers. (The percentages for the peers ranged from 54% to 76%.) Averaged over all of the department's faculty (ignoring whether they published a book), the *mean* number of books per faculty was 1.2 (Figure 1), slightly higher than average for the peer institutions.

Figure 1: SS1 book publications per faculty member

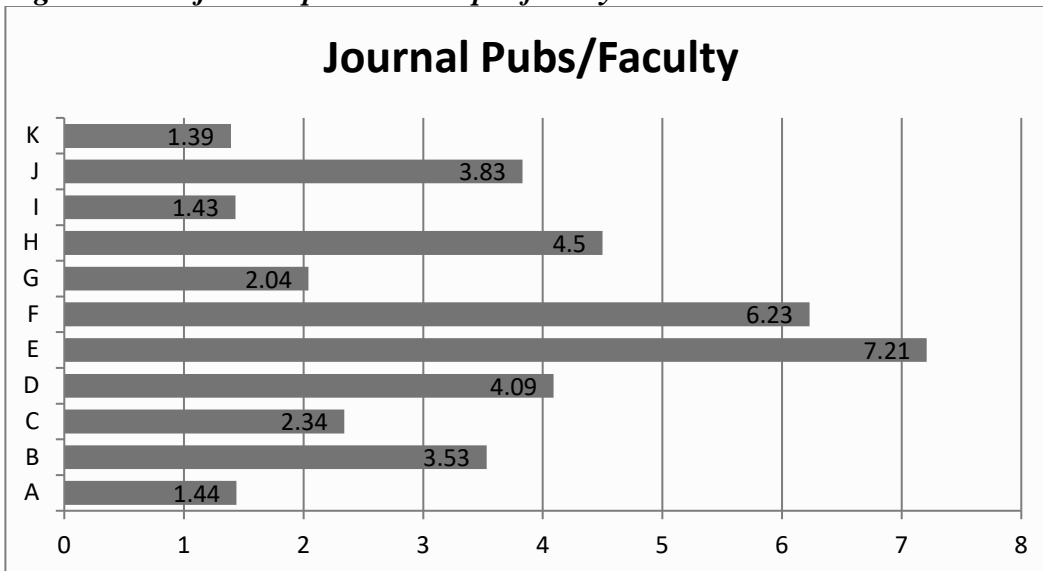


Articles

Only 39% of the KU SS1 department’s faculty published an article during the Academic Analytics data collection period. Among the peer institutions, the next lowest value was 67% and the me-

dian was between 79% and 83%. Averaged over all of the KU SS1 department’s faculty (no matter whether they published an article), the *mean* journal publications per faculty was 1.39 (Figure 2). The median value among the peer institutions was over 3.5 journal publications.

Figure 2: SS1 journal publications per faculty member



Citations

For KU's SS1 faculty, the mean number of citations of KU faculty's journal articles was 18 (Figure 3), about average relative to the peers.

In contrast to the overall citation counts, the mean number of citations per journal article was extraordinarily high (Figure 4) at 8.95 citations. The faculty of the peer institutions typically had 5 to 6 citations per journal publication.

Figure 3: SS1 Citations per faculty member

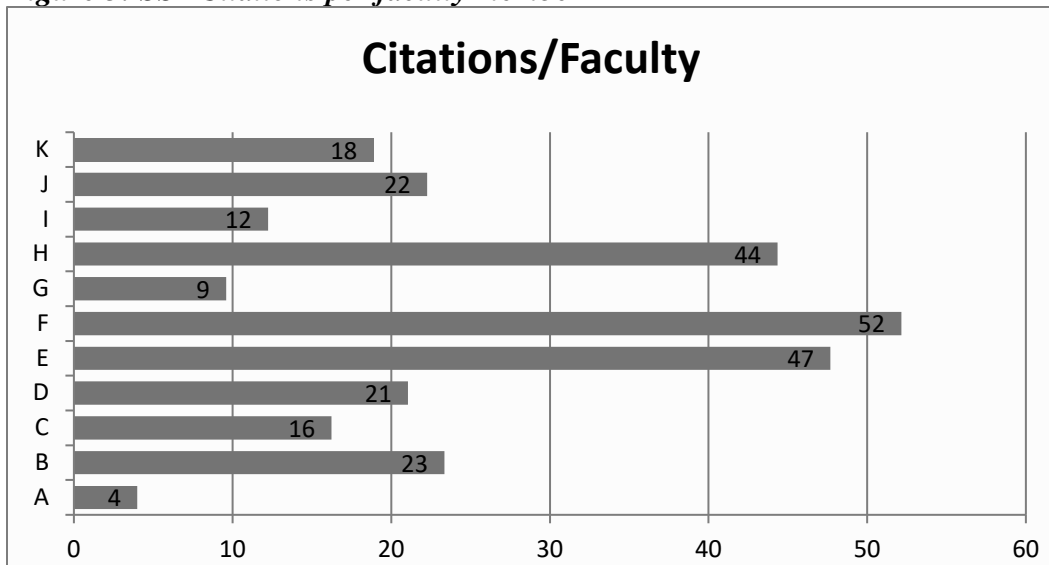
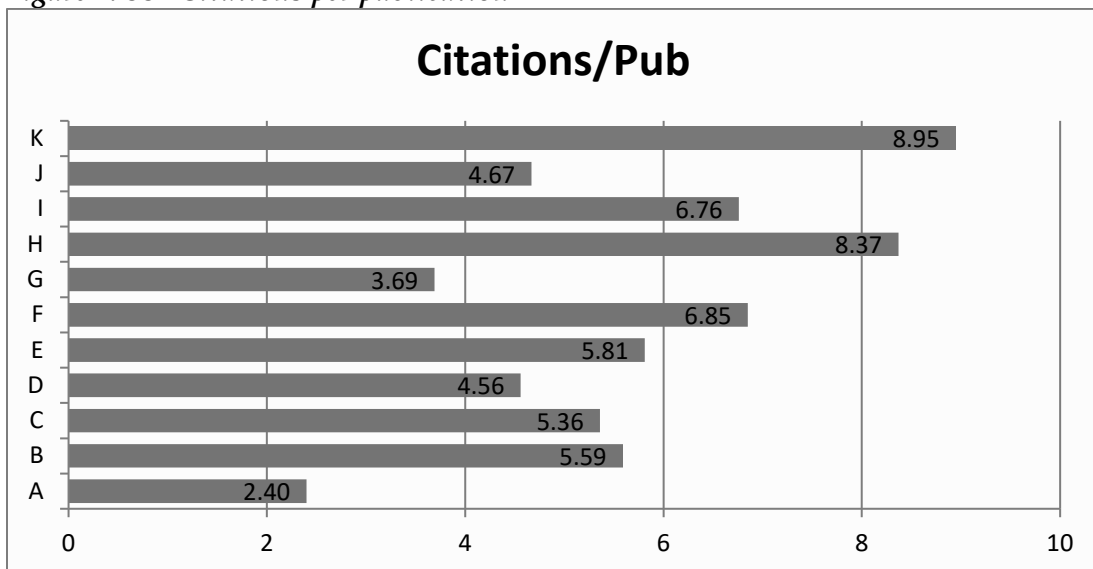


Figure 4: SS1 Citations per publication



SS1: Discussion of research productivity

Within the SS1 department, more faculty have published books (67%) than journal articles (39%).⁵ Nonetheless, the SS1 faculty have an average number of citations. The average citation value results from a balance of two findings: first, the small number of SS1 faculty who have been publishing articles, and second, the high mean number of citations per publication. Those SS1 faculty who have been publishing journal articles have produced highly cited—*impactful*—work.

Inspection of the data for individual Kansas faculty (only available to registered KU users) showed that only two of KU's SS1 faculty had been publishing journal articles. (The same two faculty members have been receiving substantial grants, in contrast to the other SS1 faculty). The two faculty who have been publishing articles, accruing citations, and winning grant awards are the department's two most senior faculty members.

The SS1 department's books-rather-than-journals publishing pattern is problematic for the university as a whole, because the AAU's metrics reward journal articles and grants more than books. The department's focus on books impedes KU's efforts to remain in the AAU.

One could argue that, within the field of the SS1 department, books contribute as much or more than journal articles, even though the SS1 departments of KU's peer institutions are far more oriented to-

wards journal publications. The argument is flawed, however, because 33% of KU's SS1 faculty did not publish a book during the Academic Analytics ten-year collection period. Even ignoring the two highly cited senior faculty, several SS1 faculty did not publish a book.

The Academic Analytics data indicate that KU's SS1 faculty productivity is generically low. According to the Academic Analytics database, only two very senior faculty members are publishing a substantial number of journal articles; the department has no young, productive journal-oriented faculty. It has been twenty years since the department last hired and retained a productive journal-oriented faculty member. The data suggest a question: *Why?* What caused the twenty-plus year drought? The answer may lie in the department's hiring, retention, and mentoring practices, or in the department's and college's tenure and promotion standards. A first step towards increasing productivity would be to identify and correct the hiring and promotion practices that led to non-productive faculty.

Natural Science – NS1

Books are sufficiently rare within NS1's field so as to obviate comparative analyses.

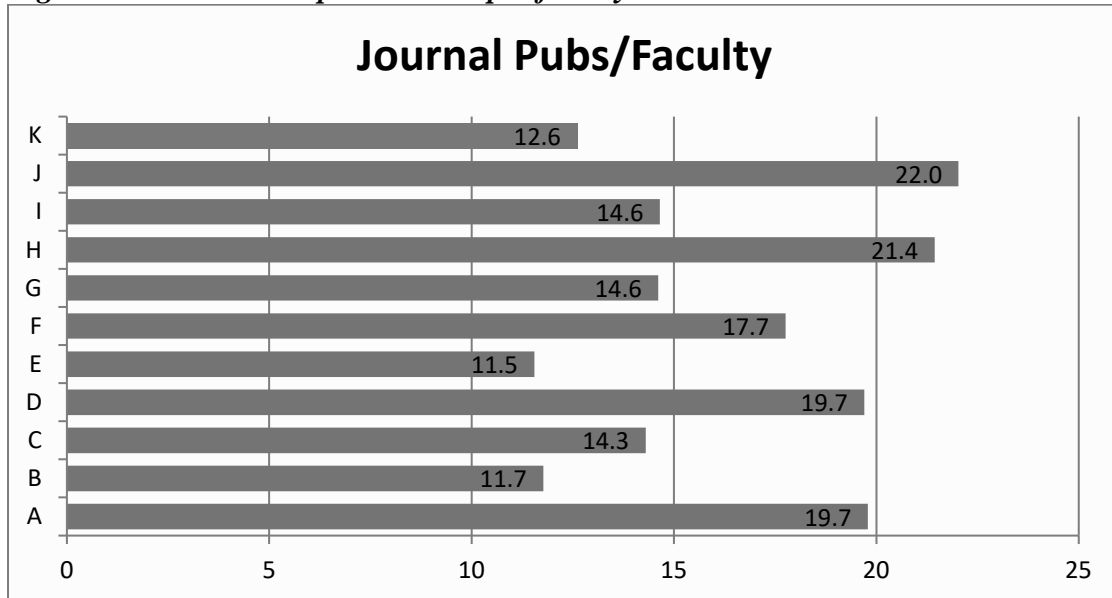
Articles

Within KU, almost all (96%) of the NS1 department's faculty have published an article during the Academic Analytics four-year data collection period. The two lowest values among the peers are 85% and 90%.

The number of journal publications per faculty member was 12.6 (Figure 5), a somewhat low value relative to KU's peers. Half of the peers had more than 15

journal publications during the same time period.

Figure 5: NS1 Journal publications per faculty member



Citations

KU's NS1 faculty accrued 185 citations during the five-year collection period (Figure 6). The value of 185 is lower than for any of KU's peers. Half of the

peers had means above 300 citations per faculty member. The highest of the peer departments had a mean almost four times that of KU.

Figure 6: NS1 Citations per faculty member

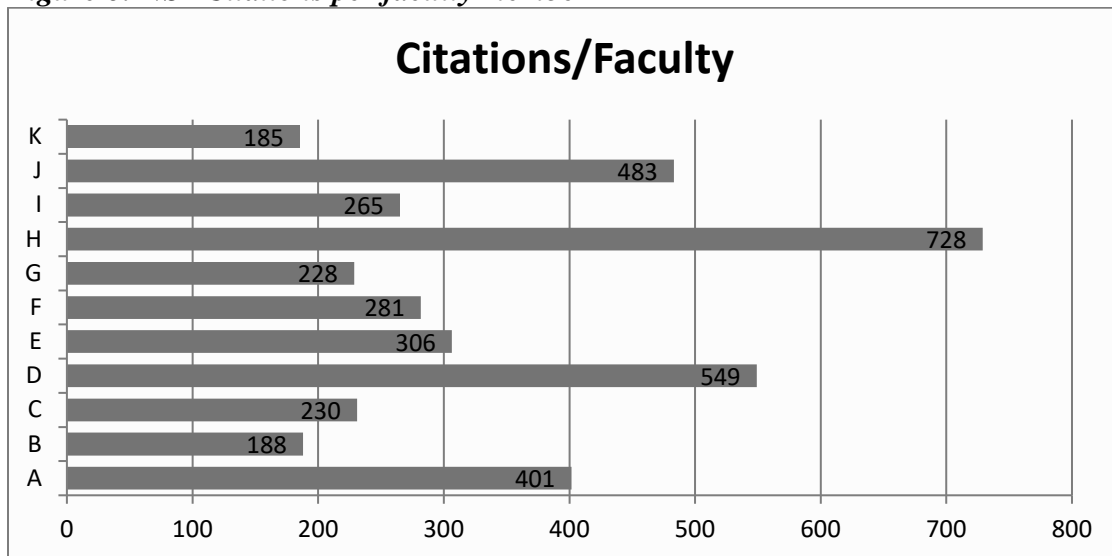
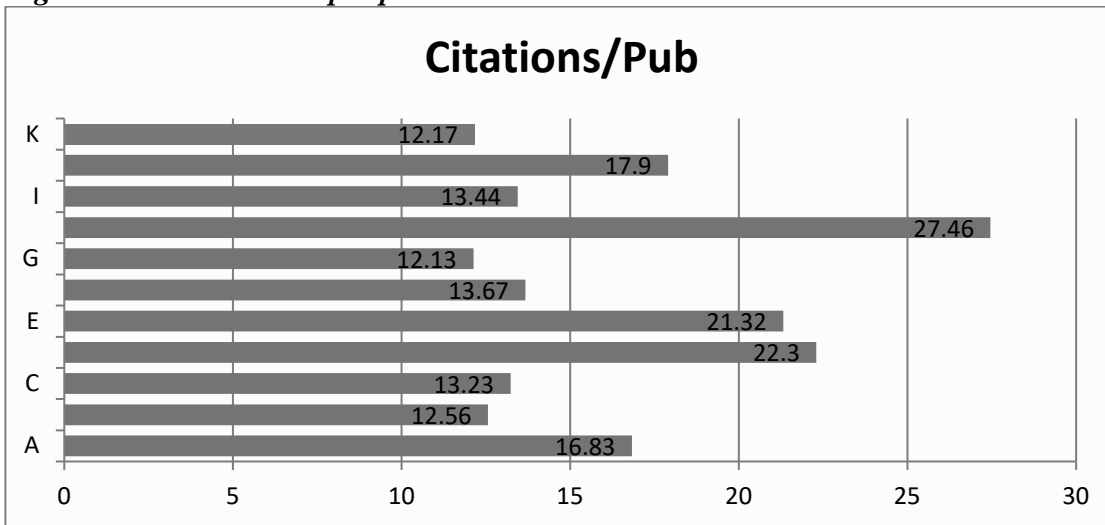


Figure 7: NS1 Citations per publication



KU’s faculty received relatively few citations compared with NS1 faculty at peer institutions (Figure 7). KU’s mean citations per article of 12.17 virtually tied with the lowest value among the peer institutions. Half of the peers averaged above 15 citations per publication.

Grants

Grant activity in the natural sciences is crucial to faculty research productivity and reflects peer confidence in the recipients’ research competence. Most (79%) of KU’s NS1 faculty had an active grant during the four-year data collection period. The percentage of KU’s faculty with a grant was higher than all but one of the peer institutions.

Figure 8: NS1 Percent of faculty with a grant

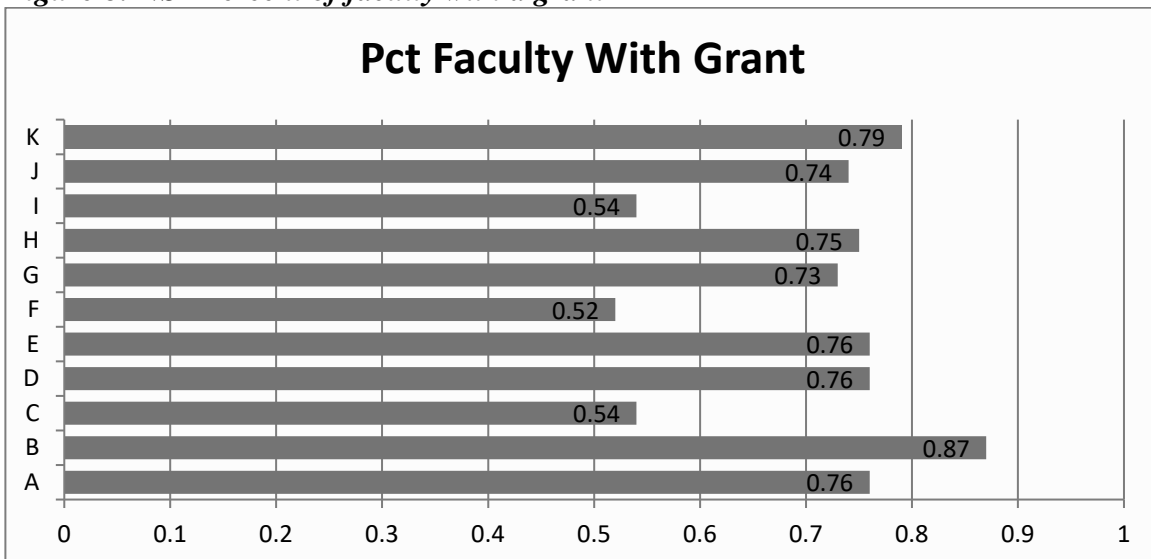
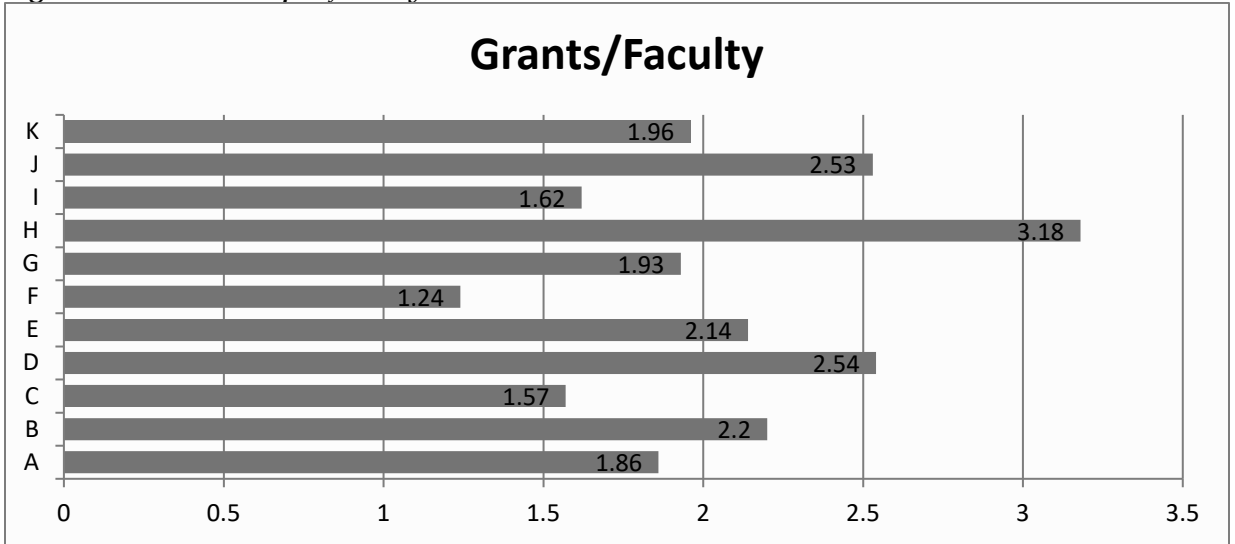


Figure 9: NS1 Grants per faculty member



Although most of the NS1 faculty at KU had a grant, the number of grants per faculty member at KU (1.96) was average compared with the peer institutions (Figure 9).

KU's NS1 department was average in grant dollars per faculty member

(\$353,000) and dollars per grant (\$180,000; Figures 10 and 11). Overall, KU's NS1 faculty were unusually likely to have one or more grant, but they obtained an average volume of grant funding.

Figure 10: NS1 Grant dollars per faculty member

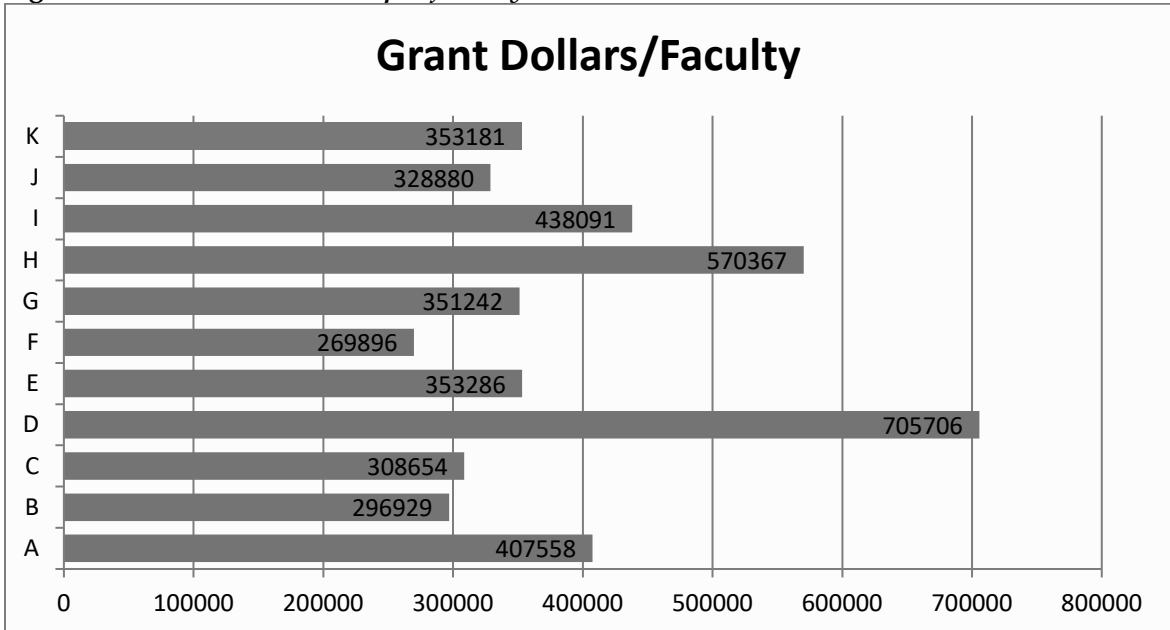
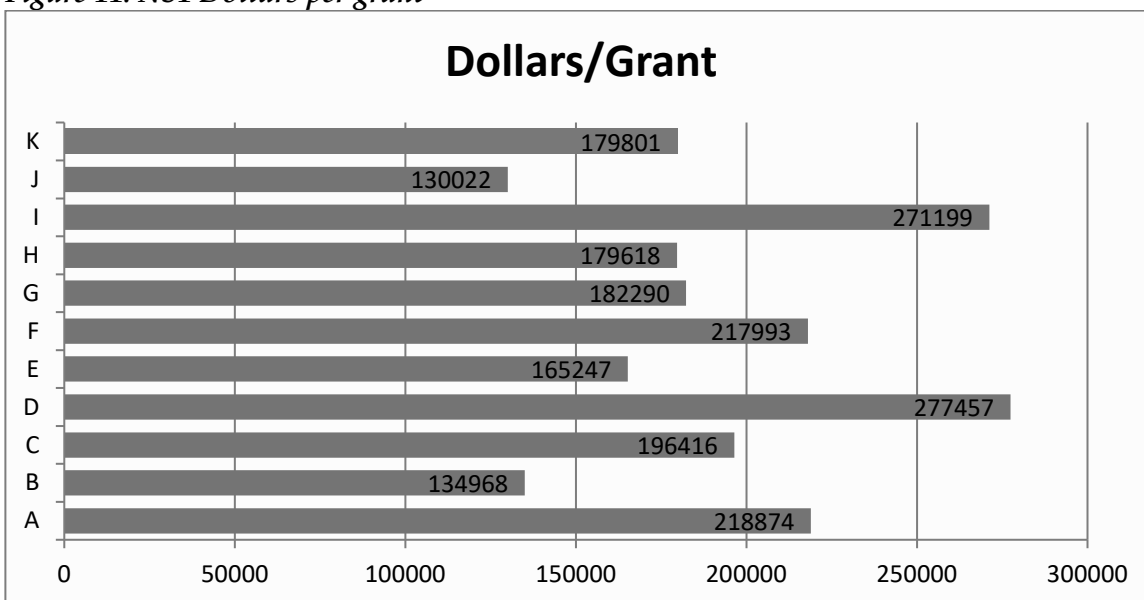


Figure 11: NS1 Dollars per grant



NS1: Discussion of research productivity

The NS1 data formed a striking pattern:

1. Almost all of KU's NS1 faculty published one or more journal articles during the 2011-2014 period; and almost all received at least one citation.
2. The number of articles per faculty member was slightly lower for KU than for KU's peers.
3. The number of citations per faculty member was extremely low for KU's faculty, as was the number of citations per publication.
4. KU's NS1 faculty received grants and grant dollars at roughly the same rate as the median values for the peer institutions.

Integrating the four points above suggests the following conclusion: The faculty in KU's NS1 department are relatively active in terms of publishing and

grant activity, but the work done at KU has a minimal impact on the field. Researchers at other institutions pay little attention to the research performed by KU's NS1 department.

The data and the conclusions suggest an essential question: Why are citations to KU's research so low; why do KU's researchers have so little impact? The question's importance demands further explorations:

1. Is the low impact of KU's research an artifact of the subfields that KU's faculty investigate?
2. Alternatively, are KU's faculty publishing "small" articles that attract little attention?
3. Are KU's faculty publishing in journals that most of their peer colleagues ignore?
4. Does the low impact of work coming out of KU reflect poor mentoring or tenure advice (e.g., "slow, steady, and unexciting work will earn tenure and promotion")?

Answering the questions requires a level of technical expertise that a university's central administration cannot possess. An external review team should examine the department's research activity and why the research impact is so low.

Humanities – H1

Books

Book publications provide the predominant medium for disseminating scholarship within the humanities. In

KU's H1 department, 42% of the faculty published a book during the 2005-2014 collection period. The 42% value is slightly low relative to the peer institutions, for which the median publication rate was 55% to 60%.

Although relatively few of KU's H1 faculty published books, the mean number of books faculty member (1.83) was slightly high relative to the peers (Figure 13).

Figure 12: H1 Percent of faculty with a book publication

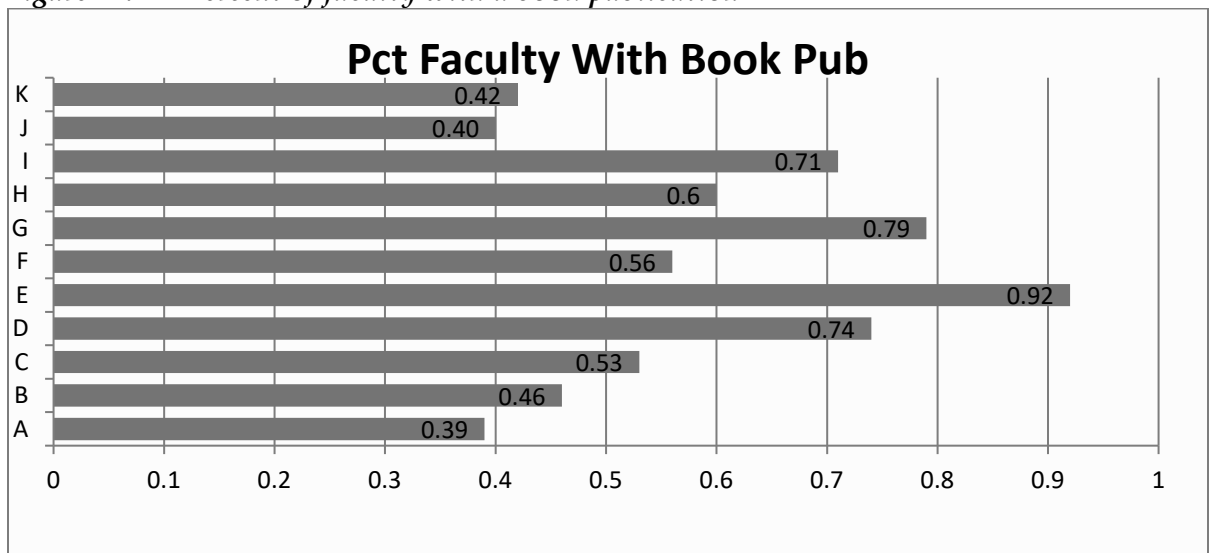
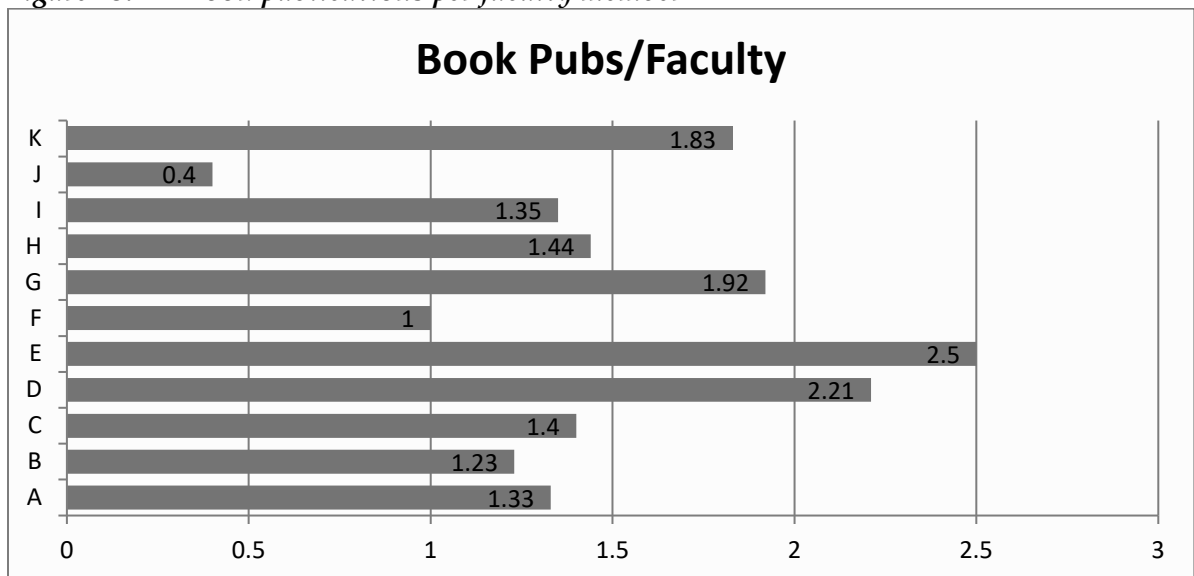


Figure 13: H1 Book publications per faculty member



The two findings suggest that those faculty members who do publish books do so at a high rate. Examination of faculty-level data revealed that the book-publishing faculty averaged an impressive 4 books each during the 10-year Academic Analytics collection period.

Articles

Most of the H1 faculty (83%) pub-

lished a journal article during the four-year journal article collection period—a high value compared with the peer institutions (Figure 14).

KU's H1 faculty published a relatively large number of journal articles (Figure 15). Only two peer institutions had higher means for number of journal articles per faculty.

Figure 14: H1 Percent of faculty with a journal publication

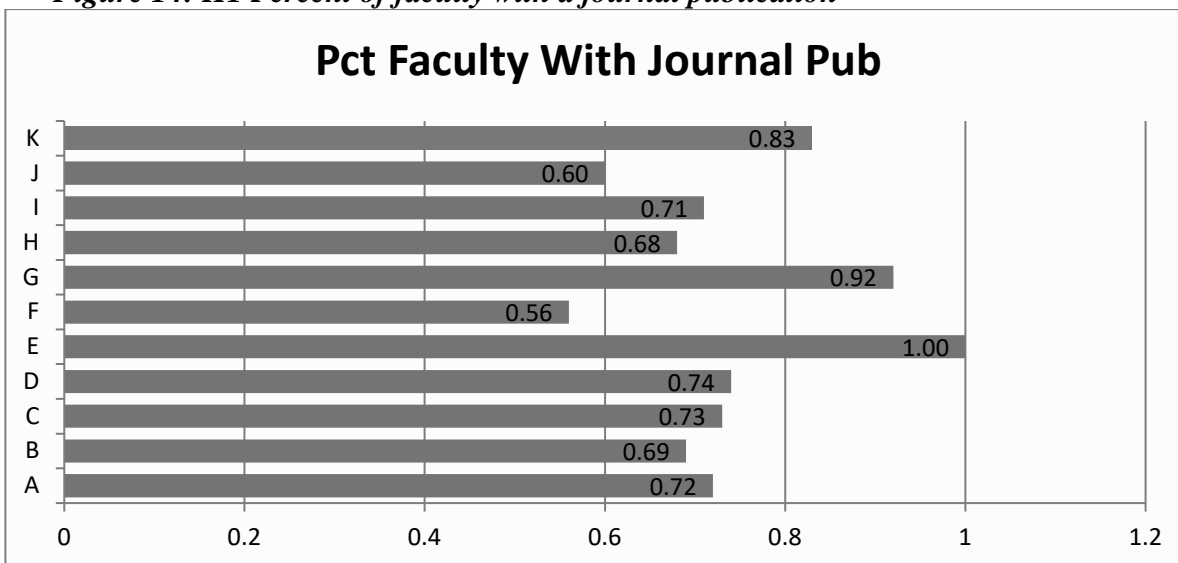
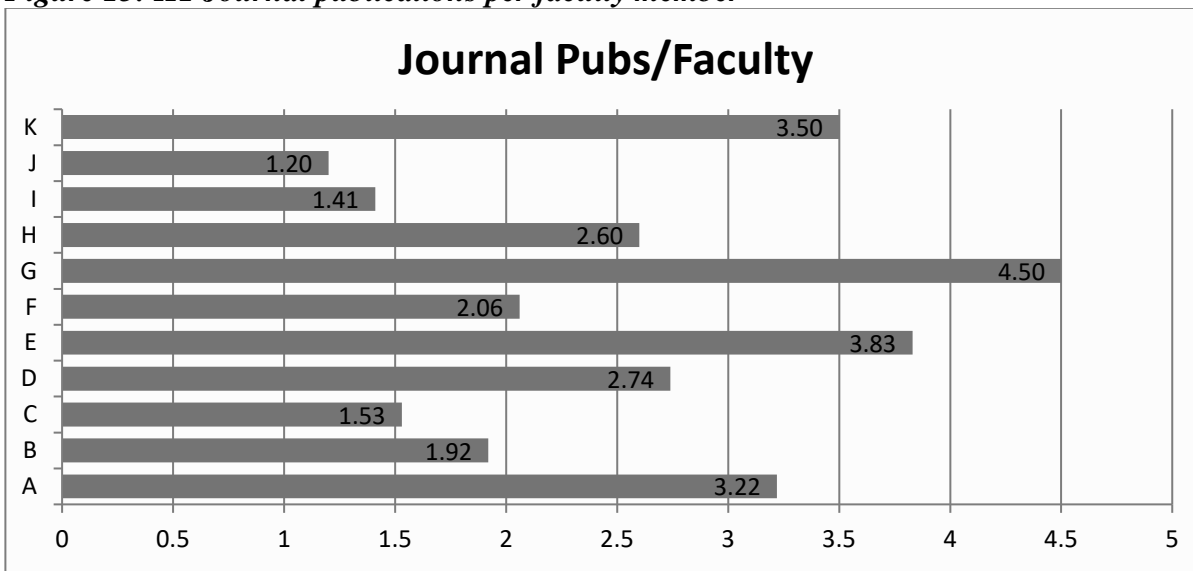


Figure 15: H1 Journal publications per faculty member



Citations

The citation data for KU's H1 faculty showed average performance relative to the peers. KU's faculty averaged 6.92 citations; only two of the peer institutions had means greater than 10 (Figure 16).

Across the peer institutions, H1 journal articles were rarely cited: a mean of 1.66 times for KU's faculty (Figure 17), and never more than 5 times each for the peer institutions.

Figure 16: H1 Citations per faculty member

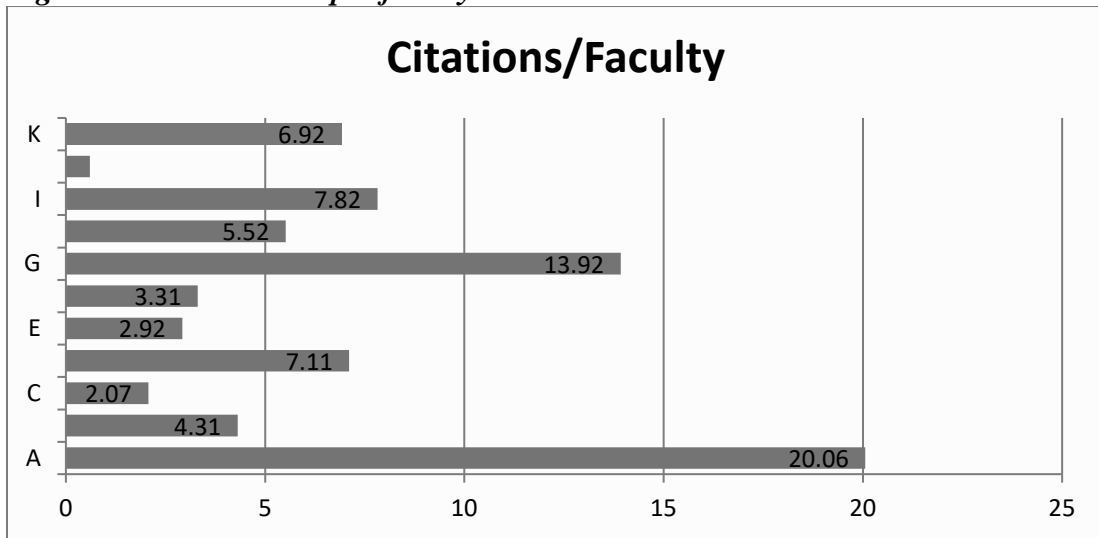
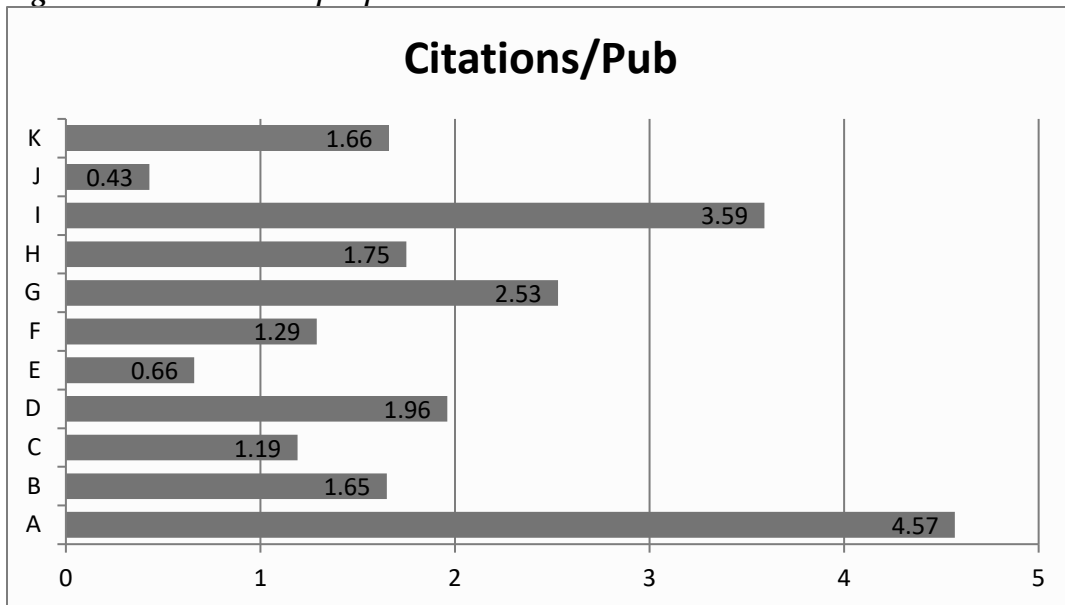


Figure 17: H1 Citations per publication



H1: Discussion of the research productivity

On the whole, the faculty of KU's H1 department have been keeping busy. Some of the faculty have a strong record of publishing books; some have a strong record of publishing journal articles.

The H1 results suggest a question: *Who* has been doing what *kind* of publishing? Are the department's faculty bifurcated, with some writing books and others writing articles? Or have the same faculty been responsible for both types of publications?

An examination of the faculty-level data showed that two senior faculty members had above-average numbers of books, and three junior to mid-career faculty members had above-average numbers of journal articles. The department's other faculty had average to below-average records in publishing books and articles.

Averaged across the entire department, H1 looks relatively productive. However, the data for individual faculty reveal that fewer than half have been producing the majority of the department's scholarly output.

Meta-metrics

The Academic Analytics database lists most measures in two forms—means and percentages as shown in the previous graphs, and the corresponding standard scores (z-scores: mean = 0, standard deviation = 1). The z-scores are computed with respect to all 409 research universities in the dataset.

The constant 0-1 scale allows one to compare departments within a university or to compare one institution to another. One can also use the z-scores to invent new indices, two of which follow:

- *Productivity Index*: The mean of the z-scores for Number of Books per Faculty and Number of Journal Articles per Faculty
- *Impact Index*: The z-scores for Article Citations per Faculty

The Productivity Index measures a department's *output* relative to department-matched peers. The Impact Index measures a department's *impact* relative to department-matched peers. For both indices, a score of $z = 0$ indicates that a department is average relative to the peer institutions. Positive scores indicate superior performance and negative scores indicate inferior performance. "Average" performance was (arbitrarily) defined as a z score between -0.2 and $+0.2$.

Values of the two indices were computed for the full set of nine departments mentioned in the *Methods* section (three in the humanities, three in the social and behavioral sciences, and three in the natural and mathematical sciences).

Productivity metric. Three of the nine KU departments have been more productive than average, five about average in productivity, and one less productive than average (Table 2). Productivity was unrelated to broad field: The above-average departments included one in the natural sciences and two in the humanities; the below-average department was in the natural sciences.

Table 2: KU Department Means for Productivity

$(z \text{ (Number Books)} + z \text{ (Number Articles)}) / 2$

Broad Field	Productivity Index	Classification
Natural Science	0.44	Above Average
Humanities	0.44	Above Average
Humanities	0.40	Above Average
Social Science	0.14	Average
Social Science	0.07	Average
Natural Science	0.02	Average
Humanities	-0.10	Average
Social Science	-0.18	Average
Natural Science	-0.24	Below Average

Table 3: KU Department Means for Impact (z (Citations per Faculty Member))

Broad Field	Impact Index	Classification
Natural Science	1.41	Above Average
Natural Science	-0.06	Average
Humanities	-0.09	Average
Social Science	-0.16	Average
Humanities	-0.17	Average
Humanities	-0.21	Below Average
Social Science	-0.22	Below Average
Natural Science	-0.33	Below Average
Social Science	-0.39	Below Average

Impact metric. Only one KU department was above-average on the impact index. That lone department had an astonishingly high mean of 1.41 (Table 3)—a higher impact score than any of the peer institutions in that field.

KU's other eight departments all had negative z -scores for impact. Four had sufficiently low impact scores to meet the below-average statistical criterion.

Discussion of Meta-metrics

With the exception of one of the nine departments, KU's faculty have been putting their time, effort, and resources into producing articles that are rarely cited. The finding raises two obvious and obviously serious questions: (a) Why have KU faculty been producing under-cited work; and (b) how can KU improve citation scores?

Questions abound: Has the University of Kansas been making poor hiring

decisions? Have faculty mentors been giving conservative advice about how to win tenure? Have KU's standards for hiring, promotion, and post-tenure review been too relaxed? Are the reasons for low citations the same or different across schools and departments?

During the last few years, the University of Kansas has tried to raise KU's research profile by hiring twelve highly productive faculty members, the Foundation Distinguished Professors. These new faculty members will "bring" their citations with them because the Academic Analytics database awards citation credit to a faculty member's most recent institution. However, these highly productive faculty members make up only one percent of the overall faculty, and their influx (which is too recent to be captured by the current Academic Analytics data) will have a minimal effect on KU's citations profile.

Examining where faculty publish may yield insight into the citation deficit. Citation measures are sensitive to the choice of journals, some of which are read more often than others. Paying attention to where researchers publish relative to journals' prominence may improve citations.

Proper marketing of by KU's faculty may provide another route for KU to raise its citation counts. For example, citations generally increase when research appears in open access venues.

Although useful, hiring foundation professors or having faculty provide open access to their publications will not and cannot substantially increase KU's citation scores. Increasing scores will require centrally led, department-by-department analyses of how KU hires, mentors, and promotes its faculty.

¹*Publications* include books, journal articles, conference presentations. More broadly, publications may include performances and exhibitions, but there currently are no standard measures of these and Academic Analytics does not include them. The present article focuses on books and journal articles.

² Egghe, Leo (2006) Theory and practice of the g-index. *Scientometrics*, 69, No 1, pp. 131–152.

³ Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences*, 102 (46): 16569–16572.

⁴ The present paper ignores Academic Analytics data on conference presentations.

⁵ A reminder: The book publication collection period covered 2005-2014; the journal article collection period covered 2011-2014.

Planning for Institutional Core Research Facilities in Uncertain Times

**Joseph A. Heppert, Ph.D., Associate Vice Chancellor for Research,
Professor of Chemistry
University of Kansas**

When I began my career at the University of Kansas over 30 years ago, university research core facilities were generally called “core service laboratories”. About three years ago during a discussion in one of our staff meetings, the directors of these facilities expressed their displeasure with my continued use of this terminology. They wanted to be referred to using language more accurately reflecting their central role in the university’s research endeavor. They were absolutely right. With that discussion KU undertook a renewed focus on “core research laboratories” or “core research facilities”.

It is an understatement to note that the vision of core laboratories as “service” units is several generations out of date. Of course, these laboratories do still serve a significant swath of the science, engineering, mathematics, and technology (STEM) researchers at the university. But the operation of these laboratories is far more diverse than the stereotypical “drop a sample off on Monday and pick up a spectrum on Tuesday” mission that was thought to dominate the service cores of the 1970’s and 1980’s. Most core laboratories now often play the part of institutionally supported research collaborators, available to tailor analytical research solutions, design new instruments, and create novel software applications to address the needs of researchers from diverse disciplines. Frequently, these core research laboratories generate independent intellectual contributions to the problems they address, and consequently need to be acknowledged as co-investigators in proposals and publica-

tions. This is a far cry from our dated vision of the role of core service laboratories.

The challenge for today’s public research universities is how to create a sustainable system of core research laboratories that serve the largest possible group of institutional investigators. Sustainability in today’s context of challenging state and federal budgets implies achieving a balance of the following factors:

1. Cost effectiveness—the institution and its researchers need to obtain the greatest possible research output for the financial commitment provided to the core research laboratory or facility.
2. Sustainability—the institution should seek to invest in core laboratories that have a sufficient client base and mission to offer the prospect of sustainable operation.
3. Adaptability—core research units need to vary their offerings of in-

strumentation and research activities based on investigator need and on the availability of convenient, cost effective alternatives in the private sector.

4. Responsiveness—leaders of core research units need to seek constant input from investigators about emerging trends in institutional research, and areas where core functions could be expanded to support emerging research needs.
5. Engagement—the level of institutional investment in core research units needs to be confirmed through researcher engagement in evaluating their effectiveness and in ongoing management (including expansion and contraction) of the institutional core laboratory and facility portfolio.
6. Outreach—where possible, augmenting internal services by offering unique research services to other universities, research institutions, and private sector partners outside of the university can assist in supporting core laboratories. Achieving a balance of these factors in a core research facility and laboratory program is essential for the vitality of the university research endeavor.

Rationale for building research laboratory and infrastructure cores

The function of core laboratories has always been about creating efficiencies in capital investment and operations that minimize the cost of research services and infrastructure for the institution. While investments in core laboratories

frequently focus on stupendously expensive capital equipment (NMR spectrometers, electron microscopes, mass spectrometers, research nuclear reactors, etc.), other significant components of institutional investment must also be factored into an analysis of core laboratory costs. Among these factors are ongoing maintenance of equipment, opportunity costs for the use of space, the cost of utilities, personnel salaries and training, the cost of maintaining compliance with federal and state regulations, and infrastructure for budgeting and account management. Though initial capital costs for the creation of these facilities can be staggering, annual support for personnel-intensive research core laboratories can dominate the longitudinal institutional investment costs.

In spite of these costs, maintaining core research laboratories can enhance the university's research efficiency beyond avoiding duplication of highly expensive capital equipment. Centralizing important, yet non-cutting edge research functions in core research laboratories can ensure that researchers have access to important collaboration partners in areas where it is impractical to hire tenure-track faculty. The expertise found in core laboratories allows faculty researchers to focus their group's activities on aspects of studies that reflect their specialty rather than cross-training researcher's peripheral techniques in a wide variety of disciplines. Finally, centralizing certain research functions in core laboratories and facilities can ensure a uniform approach to critical compliance and quality control functions.

Building a core research laboratory system

It is increasingly clear that Federal agencies also see the advantages of centralizing major core resources on a regional, national and international level. While this has been the case since the 1940's for massive infrastructure projects such as telescopes, particle accelerators, and facilities for supporting nuclear and infectious disease research, NSF and NIH seem to be turning with renewed interest to creating regional resources in high performance computing, microscopy, advanced manufacturing, and other core areas of technology.

KU began to build its core laboratory capacity during the early 1970's. Following passage of an amendment to the Animal Welfare Act (1), the Animal Care Unit became KU's first formal core research laboratory. The addition of analytical cores was supported through NSF funding in the early 1980's, and facilities that support small molecule drug discovery and high performance computing have been added throughout succeeding decades. KU Research currently supports and administers the ten core laboratories outlined below:

- Animal Care Unit—early 1970's
- Instrument Design Laboratory—early 1980's
- Mass Spectroscopy Laboratory—early 1980's
- NMR Laboratory—late 1980's
- X-ray Laboratory—early 1980's
- Molecular Graphics Laboratory—early 1990's
- Biotechnology Innovation and Optimization Center, mid-1990's
- High Throughput Screening Laboratory—early 2000's

- Microscopy and Analytical Imaging Laboratory—early 2000's
- Center for Research Computing—2013

These university core laboratories receive some degree of salary support and are under budgetary supervision by KU Research. Each laboratory has rates for research and service activities reviewed and approved by KU Research, and each lab undergoes formal performance evaluations on a 5-year rolling schedule. The smallest of these units has only two full time staff, while the Animal Care Unit has a total of 10 full time staff for veterinary and animal husbandry services. Overall, KU currently budgets \$1.8 million in support of these laboratories. Because these cores were established during different decades and serve different groups around the university, the degree to which KU Research subsidizes their cost varies between 0 to 80 percent. On average, the university provides 60 percent of the laboratory budget. Anecdotally, this percentage appears to be a common average for core laboratory support across the country, though some campuses provide little or no subsidy for their cores and others offer core services at little or no cost. Based on recent discussions among national research leaders, there appears to be little consistency in how research core laboratories are developed and managed across the country.

Rates for research and service activities offered by KU core research laboratories are established through a formal university financial accounting process using data gathered from laboratory operations. KU maintains three rates for most research activities embedded in core laboratories:

- A rate for internal investigators. This published rate does not include F&A cost recovery, because this occurs automatically for expenditures from federal grants held by KU.
- A rate for external academic researchers and non-profit agencies. This rate combines both the internal investigator rate and the accompanying F&A recovery, and adds an additional 5 percent fee for administrative costs.
- An external market rate. This rate reflects the cost of obtaining similar services in the private sector, and is applied to all for-profit entities seeking core laboratory research and services.

Rates are, at most intended to recover operating costs, not to generate excess funding. In spite of the importance of covering operating costs, there are practical constraints on the internal rates the core laboratories can charge, and the level of rate increases they can impose in any annual period. Investigators can and sometimes do shop for the prices of similar services at other institutions. This can impose a practical limit on the price of specific research services. When researchers outsource research services available at their home institution to core laboratories at other institutions, this drives up the cost of providing services to other researchers by decreasing the financial competitiveness of their own core laboratories. In spite of this fact, a large differential between the cost of services at the home institution and those in competing academic laboratories can result in an exodus of business from specific cores. Price increases face a practical limit as

well, because the average 4-year Federal grant cycle assumes a reasonably constant rate for access to specific research resources. Finally, Kansas statute also forbids State institutions from unfairly competing with private sector service providers, which explains why core laboratory rates for private sector research partners are pegged to either the external market rate or the total cost of services (whichever is higher).

The roles core laboratories undertake in their work with university researchers has continued to diversify as core laboratory directors see new opportunities to serve as collaborators. KU has prided itself on allowing all trained researchers, including undergraduate students hands-on access to instrumentation. Since some core laboratories are engaging in collaborative research rather than in routine analyses, the ability of students to be hands on users of some core facility resources is changing. Studies that require more intellectual input as the project develops tend to be performed entirely within the unit. Additionally, some of the core research laboratories almost exclusively serve an internal clientele where hands-on involvement by researchers from the laboratory might be appropriate, while other cores work with a diverse range of internal and external investigators.

There are many other core laboratories hosted in various units at KU. Some of these are longstanding cores funded within research units such as the Higuchi Biosciences Center or the Life Span Institute. Others, such as the Protein Production and Protein Structure cores, have been funded through a 15-year maturation period with NIH-COBRE funding.

The expectation is that many of these latter cores will demonstrate their utility and sustainability through building a user base and be assimilated as university core laboratories once they “graduate” from COBRE support. Though KU’s central administration establishes rates and sets invoicing policies for other core laboratories, we do not formally oversee their finances or provide direct monetary support for their operation.

Building a culture around the development and use of institutional core laboratories at KU requires several key components. First, there must be an institutional commitment to funding and supporting such laboratories. The university must either have sufficient centralized research funding to sustain laboratory operations, or academic units must band together and engage in priority planning to fund a range of core laboratories. Second, principle investigators must jointly commit to support the core laboratories. This means participating in core laboratory governance and evaluation, working with research leadership when core laboratories are not serving investigator needs, and writing contributions to core support and maintenance into external grants and awards. Matching the financial support KU provides for the institution can continue to support the widest possible range of core laboratory services. Third, in order to optimize laboratory function, the university must have a strategy for gathering formative user input on core laboratory function and longitudinal input on the effectiveness of core laboratories, and must engage investigators in discussions about sun-setting core laboratories when their functions no longer serve the research community.

Suggested best practices for building core laboratories

The following is a concise summary of suggested best practices for creating a robust system of core research laboratories:

1. Cost effectiveness:

- University core research laboratories undergo a monthly (or quarterly) financial review.
- Subsidize cores only to the extent necessary to maintain competitive costs for services.
- Subsidies and service rates must be kept in balance—requesting fees for facility usage in research grants leverages institutional resources and expands the number of core laboratories the institution can support.

2. Sustainability:

- Subsidized university cores need to have a sufficient base of clients to project financial stability.
- The function and client base of proposed cores need to be fully described prior to approval for rate setting.
- Successful core laboratories depend on building a culture of community responsibility.
- Rates will not be established for non-university cores when these services are available in a university-subsidized core—dilution of the client base is a recipe for financial failure.

3. Adaptability:

- Using external services that are available in a subsidized core is a signal that the university should not be supporting that core.

- Services should not be offered if they are available from external providers at lower costs.
 - Services that are broadly embedded in individual labs generally should not be offered in cores.
- 4. Responsiveness:**
- Institutionally supported core laboratories must be available for all-comers within the university.
 - All university subsidized core research laboratories and their directors undergo a formal internal review every 5 years.
 - Subsidized university cores either need to work for clients or they need to be reorganized so they do work for clients.
- 5. Engagement:**
- All core research laboratories must have a user advisory committee.
 - The director must meet with this group on a regular basis.
- 6. Outreach:**
- Engagement of private sector clients is strongly encouraged for all core research labs—given costs of operation, it is probably essential for some.

Case study: Construction of a new nanomaterials clean room core laboratory in the KU Central District project

In support of a growing sector of university researchers focusing on nanomaterials fabrication for energy conversion, biomedical analysis, and implantable biomaterials, KU made a decision to include a new clean room core facility space in the footprint of the Integrated Science Building in KU's Central District Project, see Figure 1. KU's Central District is a nearly \$400 million construction

project stretching diagonally from 15th Street and Naismith Drive in the north east area of central campus to 19th and Iowa Streets in the south west. Clean room spaces are among a small group of laboratory spaces—others include animal care space, biosafety laboratory level 3 & 4 spaces, GLP manufacturing spaces, and spaces for human clinical trials—that are among the most expensive spaces for universities to construct and maintain. The cost of maintaining such facilities can stem from hazard management and regulatory oversight of experiments conducted in these units, and, particularly in the case of clean room spaces, from the annual cost of supporting personnel to actively manage and provide oversight of facility operations. A careful plan for the new clean room core was in the university's best interests to ensure the maximal utility and sustainability of the unit.

KU currently has two clean room environments. As shown in Figure 2, one of these is a 3,000 square foot (sf) dedicated-user space in Malott Hall, a 60-year old building on main campus. This space is focused on the development of photophysical devices for energy harvesting. The other is a 2,000 square foot multi-user space focusing on the generation of biosensors for detection and study of cancer and other disease states. KU's Central District project was originally scheduled to host two cleanroom spaces: A new 6,000 square foot dedicated clean room space in the new Earth, Energy and Environment Building replacing the photophysical device space in Malott Hall, and a 15,000 square foot multi-user core clean room space located in the new 180,000 square foot Integrated Science Building. Executing this plan would have left KU

with 23,000 square feet of clean room space in three sites on the main campus. Clean room construction can cost up to \$1,000 per square foot and cleanroom space of this magnitude approaches that of small-scale commercial production facilities. Given these factors, the cost of construction and operation of the new spaces would have monumental initial and ongoing commitments for KU. Just the cost of maintaining and operating these facilities would likely have topped \$4 million per year. Moreover, most universities operating successful clean rooms for basic materials and biomaterials research support at most 5,000 square feet of multiuser space. Based on continuing design discussion and ongoing analyses of researchers needs, KU decided to re-scope the project, focusing on constructing a centralized facility that would maximize clean room functionality for multiple investigators.

The resulting decision was to close the existing satellite facilities and build a single 5,000 square foot multi-user cleanroom space and an associated 2,000 square foot dedicated-user cleanroom space centrally located in the new Integrated Science Building. This strategy would create new, more energy efficient spaces and create a single space for personnel engaged in clean room management. These spaces are sufficient to host the \$3.5 million of nano and microfabrication equipment we intend to provide for core facility researchers. We anticipate that this facility will cost a minimum of \$800,000 per year to operate.

In light of this cost, we have sought to create a facility that can become a unique regional resource for other academic partners and private sector R&D projects

requiring device fabrication in a clean room environment. Among the shared resources contained in this facility, we expect to offer:

- Class 10,000, 1,000 and 100 space
- Photolithography and chemical etching
- Nano-imprinting and embossing
- Sputtering and molecular beam epitaxy
- Device fabrication and wire bonding
- Device characterization and analysis
- Biomaterials and materials sample preparation areas
- “Gray” space for sample and device preparation

We anticipate not only widespread use of this facility by KU researchers, but an aggressive campaign to market this resource to private sector partners.

We believe a wide range of research focus areas will benefit from this state of the art facility, including the preparation of energy harvesting devices, the study of new implantable biomaterials, and the development of biosensors for the detection of circulating markers. To bolster KU’s research expertise in some of these areas, we recently hired Professor Steve Soper as a Kansas Foundations Professor. Professor Soper’s research, briefly outlined in Figure 3, targets the detection and identification of circulating tumor cells, extracellular DNA, and exosomes as potential markers for metastatic cancer and other human diseases. His research, see Figure 4, uses nano-engineered flow devices to collect and conduct real-time analysis circulating markers at the single cell or exosome level from small samples

of plasma. This type of rapid bedside liquid biopsy will dramatically reduce the time required to diagnose and develop genetically targeted treatments for metastatic and pre-metastatic tumors. His research programs will make heavy use of the new clean room core.

Conclusion

At KU-Lawrence, our developing understanding of best practices in the management of our research core laboratory portfolio was of great assistance as we engaged in the conceptualization and design of the new multi-user clean room core facility. We intend to continue working with KU investigators and core laboratory directors to refine these concepts for the operation of all KU core research units.

Acknowledgements

I wish to thank Professor Steven Soper for the allowing the use of diagrams depicting his research. Dr. Soper, Professor Judy Wu, and Dr. Ryan Grigsby provided extensive input on the design of the new KU clean room core facility.

References

P. L. 94-279, Animal Welfare Act Amendments of 1976

Figure 1. Artist's rendering of the Integrated Science Building in KU's Central District Project



Figure 2. Current and initially planned distribution of clean room spaces on the KU-Lawrence campus as part of the Central District Project. (KU campus map © Google Maps.)

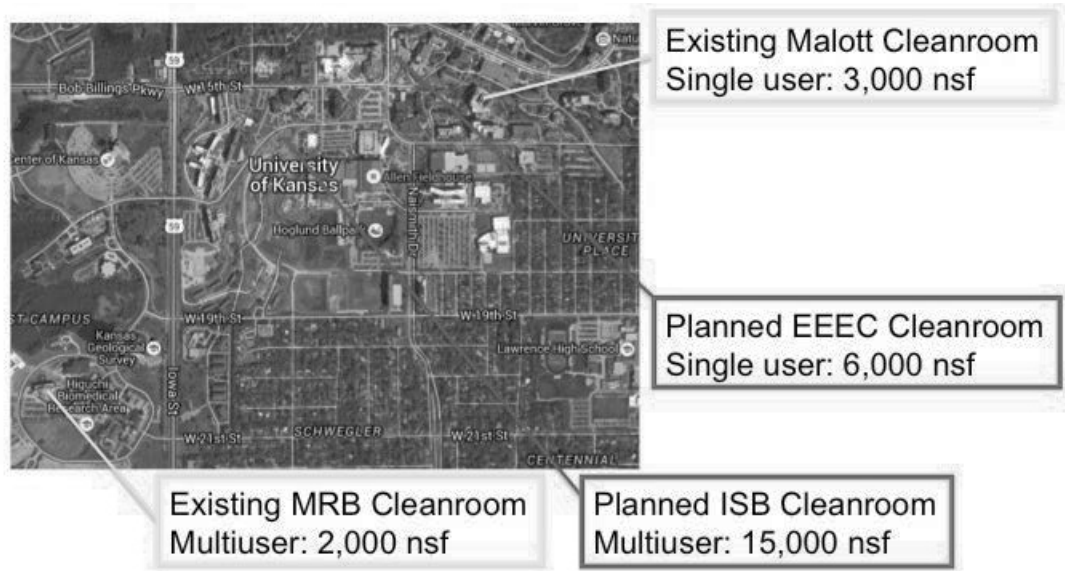


Figure 3. Summary of research themes of KU Foundation Professor Steven Soper

Blood Markers for Managing Complex Diseases

- *Circulating Tumor Cells (CTCs)*
 - Exfoliated cells from primary or secondary neoplasms and have been implicated in metastasis
 - Various types of CTCs
 - Challenge – 1-100 CTCs per mL of blood
- *Cell-free DNA (cfDNA)*
 - Isolated from plasma and has a median size of 160 - 180 bp
 - Generated from diseased cells as well as non-diseased cells
 - Disease associated load only 0.01-0.1% of total cfDNA content
 - Common isolation technologies show poor recovery (<40%)
- *Exosomes*
 - 30-120 nm in diameter that contain nucleic acids and proteins
 - Continuously secreted from various cells
 - Difficult to isolate from whole blood
 - Can use immunoaffinity techniques to isolate diseased exosomes
- *Diseases* – Cancer, Stroke, Infectious Diseases, Cardiovascular diseases, Pre-natal diagnostics.

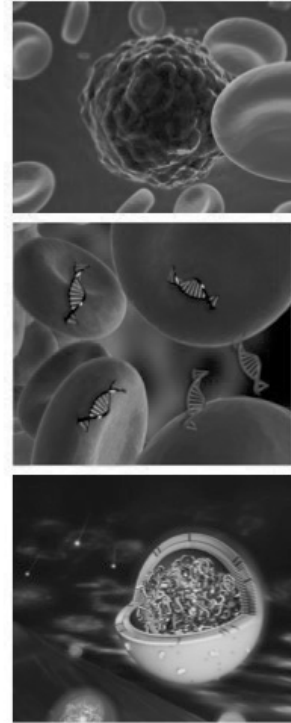
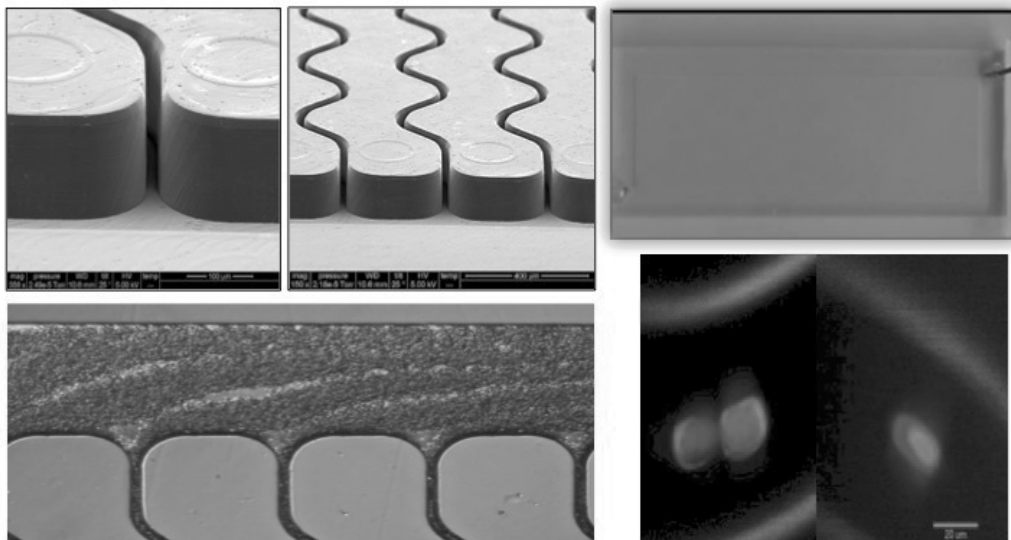


Figure 4. Nano-engineered flow analysis systems created in the Soper laboratory.

Liquid Biopsy Platform



1. Recovery = 97%
2. Purity >80%

3. Startup Company for Commercialization
4. Product Launch – January, 2017

Enhancing University Research Through Innovations in Graduate Education

Sarah C. Larsen, Associate Dean, Graduate College
Professor, Department of Chemistry
University of Iowa

Graduate education plays a critical role in the research infrastructure at research universities in the United States. The research experience is central to the doctoral degree and is closely connected to the university research enterprise as well as faculty productivity, particularly in Science, Technology, Engineering and Mathematics (STEM) disciplines. Similar to higher education considered broadly, graduate education faces many challenges including financial support for graduate students, effective diversity and inclusion efforts, and career transparency and preparation. In this paper, innovations in graduate education are presented as ways to meet these challenges.

1. Introduction

Graduate education plays a key role in university research. Specifically, graduate students are a critical component of the human capital supporting university research and innovation. In the recent publication, *Public Research Universities: Why They Matter*, published by the American Academy of Arts and Sciences in 2016, the public research university (PRU) is described as integral to the nation's core research in science, medicine, engineering and technology.[1] At PRUs, research is accomplished through the combined research efforts of faculty, graduate students, postdoctoral associates, undergraduate students, and research staff. From the graduate education perspective, PRUs award 65% of all masters' degrees and 68% of all research doctoral degrees worldwide.

The central role of graduate education to research was similarly articulated in *The Path Forward: The Future of Graduate Education in the United States* published by

the Council of Graduate Schools and the Educational Testing Service in 2010. In this report, it was stated that: "The global competitiveness of the US and capacity for innovation hinges fundamentally on a strong system of graduate education." [2] *The Path Forward* report also projected that between 2008 and 2018, 2.5 million additional professional jobs will require graduate degrees.[2] These perspectives attest to the integral role of graduate education to innovation, to university research and to the significant role of the PRU.

However, graduate education is not immune to the challenges faced by all of higher education. The *PhD Completion Project* data indicated that doctoral completion rates and time to degree varied across fields of study with engineering having a 10-year doctoral completion rate of 64% compared to the humanities which had a 10 year completion rate of 49%.[3] Overall, less than 25% of doctoral students completed degrees within five

years and approximately 57% completed degrees within 10 years. Financial support topped the list of critical elements contributing to doctoral completion with mentoring/advising and family support also being cited as important. In Section 2, several different aspects of financial support for graduate students will be examined.

The experiences and success of underrepresented minority (URM) students in doctoral education is another topic of discussion. The data collected in the *Survey of Earned Doctorates: 2014* indicates an overall upward trend in the number of doctorate degree recipients for Black/African American students and Hispanic/Latino students over the past 20 years.[4] Similar gains have not been observed for American Indian or Alaskan Native students. While the overall upward trend is encouraging, there are concerns about completion and about climate and inclusiveness. Diversity and inclusion in graduate education will be considered in more depth in Section 3.

Another aspect of doctoral graduate education that has been widely discussed is the misconception that the majority of doctoral students pursue tenure track academic careers. As research universities, such as PRUs, have faced intense budgetary crises, instructional needs are increasingly being met with nontenured and adjunct faculty. As a result, the availability of tenure track academic positions has not kept pace with the number of students earning doctorates. Increasingly, newly minted doctorates must find careers outside of traditional academic positions. About one half of new doctorates begin careers in business, government

and nonprofit organizations with variations observed by field of study. [5] Employers have noted that doctoral graduates are innovative and talented researchers but lack some of the “transferrable” or “soft” skills needed to be successful in a range of different careers. Employers suggest universities create stronger connections between graduate school curricula and workforce/employer needs.[5]

In response, graduate colleges have extended their mission to serve graduate students by developing more robust professional development offerings at the institutional and program level with the goal of better preparing students for academic and nonacademic careers. These efforts aim to facilitate the development of students’ nontechnical skills in preparation for a broader range of career outcomes. The issue of career transparency and professional development will be explored in section 4.

2. Financial Support for Graduate Education

In a recent study of PhD completion and attrition by the Council of Graduate Schools, financial support was deemed the most significant factor impacting doctoral completion.[3] Financial support models have been explored in several recent studies that have cataloged various modes (research or teaching assistantship) and sources of funding. The National Science Foundation cataloged the primary sources of funding for graduate students overall and by discipline for the time period 2004-2014.[4] The results of the study indicated that research and teaching assistantships and fellowships account for the largest percentages of

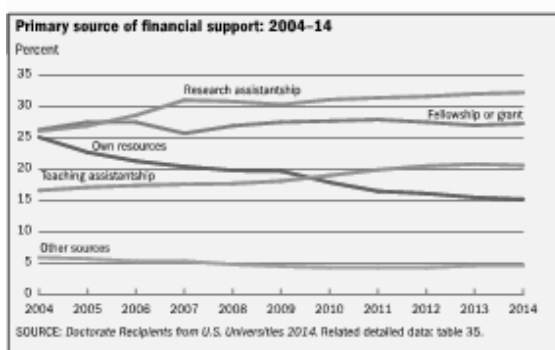


Figure 1. Primary source of financial support for doctoral recipients. Reproduced from reference 4.

support since 2010 (Figure 1). The percentage of students funded with their own resources has declined over this time period.

This report also considered support by field of study. Disciplinary trends emerged from the data as shown in Figure 2. Research assistantships account for the largest single source of support in the physical sciences and engineering while teaching assistantships are the largest source of support for the humanities disciplines. In contrast, doctoral students in education fields tend to rely heavily on their own financial resources. This variation across fields indicates that the funding challenges vary amongst the different disciplines and therefore, a multifaceted approach will be needed to address this issue.

In a recent study, the analysis was extended to examine federal funding expenditures by personnel categories which showed trends in how federal dollars were distributed across faculty, graduate students, undergraduate students, postdoctoral associates and staff. Weinberg and coworkers examined research expenditures as part of the UMETRICS

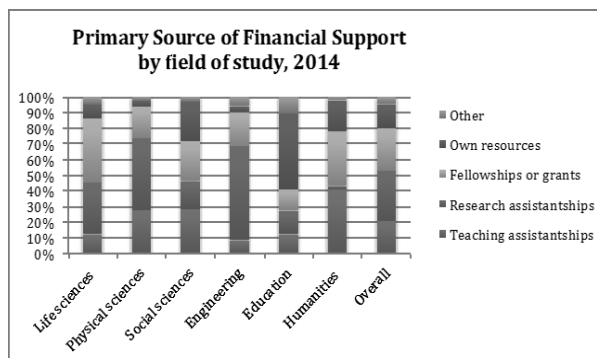


Figure 2. Primary source of financial support by field of study for doctoral recipients. Data obtained from reference 4.

initiative and found that overall approximately one third of the personnel supported were graduate or undergraduate researchers.[6] Approximately 10% were postdoctoral associates. The composition of the workforce varied according to funding source. Further, this study suggested that any changes in federal funding policies have the potential to have large impacts on graduate education and this impact varies by field of study. There are ongoing discussions in different STEM fields about the best model for graduate student support and whether this should be primarily through fellowships awarded to students or through research grants to faculty Principal Investigators. In the report, *Advancing Graduate Education in the Chemical Sciences* by the Society (ACS), the recommendation reached was that the financial support for graduate students in the chemical sciences is weighted too heavily toward individual research grants.[7] The report suggested that this can create a potential conflict of interest between the productivity of the Principal Investigator (usually a faculty member) and the educa-

tional best interests of the graduate student. The report suggests that financial support provided directly to graduate students would result in a better balance between research training and career preparation of graduate students.

In *The Path Forward*, several recommendations for financial support for graduate education were discussed.[2] These recommendations included advocacy for increased federal funding of research through research grants, increased fellowships, including fellowships to broaden participation, and funding for internships and international experiences. Business/university partnerships were proposed for funding graduate students.

Universities should engage in dialogue with various constituencies including private donors, federal funding agencies and industrial partners to provide the financial resources necessary to support graduate students across the different disciplinary areas. The ultimate goal is to provide all incoming doctoral students with five to six-year funding packages that may include combinations of research, teaching assistantships and fellowships. The rationale is that stable funding packages will allow doctoral graduate students to focus on their research earlier in their careers by alleviating financial stressors. Additionally, varying the sources of financial support across a graduate student's career will ensure that graduate students' preparation is well-rounded and comprehensive. They have the opportunity to train in the lab, to teach, and to focus on their own research unfettered by the demands of an in-service position.

3. Diversity and Inclusion

Diversity and inclusion are critical to graduate education and central to the achievement of excellence in research universities. One goal of diversifying the student body is that this diversity will be reflected in the future workforce and will lead to innovation and long-term economic growth. Inclusion is central to the success of graduate programs because diverse learning environments improve student outcomes.[8] The link between diversity and excellence, particularly in scientific fields, is rooted in the belief that solving complex problems requires teamwork and is facilitated by diverse perspectives.[9]

Participation in doctoral education by U.S. students or permanent residents who are members of underrepresented minority (URM) populations has increased over the last 20 years. For example, the numbers of doctorates earned by Hispanic or Latino students has doubled from 1994 to 2014 while the numbers of doctorates earned by Black or African American students has increased by 70% as shown in Figure 3. Despite this progress, Black/African American, and Hispanic /Latino students are still underrepresented in graduate education relative to the representation of these groups in the U.S. population. [2]

Efforts are in place to increase the participation of URM students in graduate education. Many of these efforts have focused on recruitment and admissions processes. The Council of Graduate Schools recently released a report on *Holistic Review in Graduate Admissions*. [8] Holistic review refers to the consideration of a broad range of credentials beyond quantitative measures such as

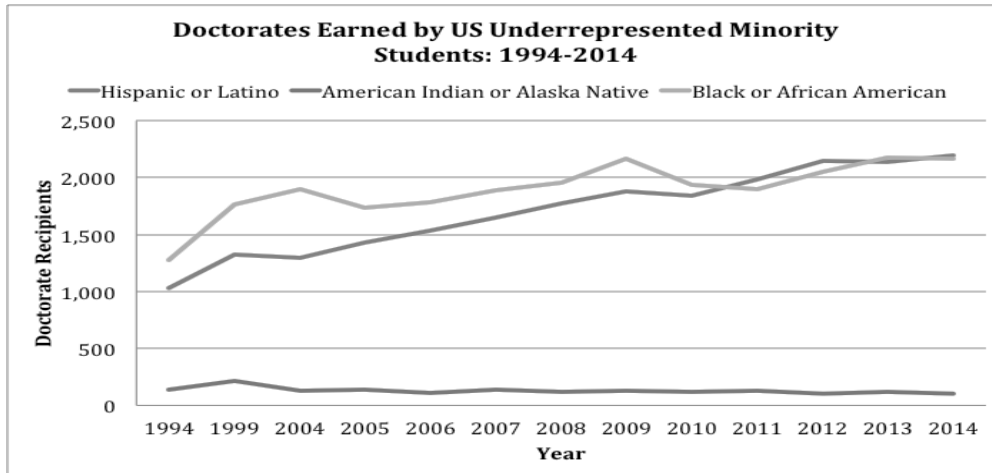


Figure 3. Doctorates earned by URM students. (Data obtained from reference 4.)

grades and test scores to evaluate admissions candidates. Holistic review is generally associated with improving diversity in higher education broadly. Holistic review involves consideration of noncognitive or personal traits such as creativity, leadership, or persistence in addition to more traditional quantitative measures. One challenge to implementing holistic review in graduate admissions is that graduate admissions tends to be decentralized and labor intensive. The CGS report[8] includes a list of promising practices:

- Articulated commitment to diversity at the institution
- Data analysis to identify gender and/or race-based patterns in admissions
- Faculty development related to admissions (e.g. appropriate use of GRE scores, preferred order for file review)
- Clear communication and coordination between recruitment and admissions
- Use of rubrics for applicant evaluation which include noncognitive measures.

To further develop holistic review as an effective strategy for graduate ad-

missions, compelling data connecting admissions criteria and graduate student success is needed.

In addition to recruiting and admissions considerations related to diversity, there is a need for increased retention and completion efforts to support the success of URM graduate students. For example, data indicates that URM doctoral students in STEM fields have lower completion rates and higher attrition rates relative to all STEM doctoral students.[3] The *PhD Completion Project* found that for U.S citizens and permanent residents, the ten-year doctoral completion rates were 55% for White students, 51% for Hispanic/Latino students and 47% for Black/African American students.[3] *The Doctoral Initiative on Minority Attrition and Completion (DIMAC)* focused on URM doctoral students in STEM disciplines.[10] The findings indicated that the seven year completion rates for Black/African American students and Hispanic/Latino students were below 50%. Recommendations from the DIMAC project for increasing URM doctoral completion and retention included[10]:

- Early and frequent interventions
- Enhanced academic support
- Monitoring and evaluating interventions
- Cultivating a climate of diversity and inclusion

Creating an environment where URM graduate students can thrive depends on increased institutional initiatives aimed at improving campus climate around inclusion and facilitating graduate student success with attention to the specific experiences of URM students.

5. Career Transparency and Preparation

With more than half of all doctoral graduates finding employment in non-academic careers, there is a need for earlier exposure to multiple career pathways in graduate education.[2, 5, 11] The broad overview of doctoral career pathways includes: 1) faculty positions at research or teaching colleges and universities 2) non-academic research careers (industry, government, startup company); and 3) non-research careers (consulting, science writing and policy, patent law).

In a recent study, Zolas and coworkers combined data from UMETRICS on graduate students supported by funded research and from the U.S. Census Bureau.[12] Analysis of the data showed that for doctoral students receiving their doctorates from 2009-2011, approximately 40% obtained industrial jobs. Interestingly, geographical clustering in employment was also observed near the university where the student trained.

Beyond exposure, it is generally agreed that graduate students should also be provided with enhanced professional development opportunities that will complement traditional research

training and enhance employability. This call is echoed by the recent report *The Path Forward*, which suggested that to be competitive globally, U.S. universities should offer professional development programs for graduate students so that they can develop career and “soft” or transferrable skills.[2] The ACS report, *Advancing Graduate Education in the Chemical Sciences*, concluded that “current educational opportunities for graduate students, viewed on balance as a system, do not provide sufficient preparation for their careers after graduate school.”[7] Further, the report called for university and government leaders to advance opportunities for graduate students to develop critical professional skills.[7]

Nationally, graduate students report increased interest in nonacademic careers and acquiring the skills that would support this pursuit.[13, 14] Despite this interest, many universities do not have a systematic way to integrate professional development activities into the lives of graduate students. Unlike undergraduate offerings, graduate student professional development often lacks a clear roadmap or campus infrastructure to support it.[15] Without career education or tools to reflect on career decisions, a large number of graduate students find themselves in a holding pattern as post-doctoral researchers, where despite decreased interest in a faculty career, they follow the trajectory that appears most familiar.

This issue has been acute in the biomedical sciences where, since 2011, fewer than 20% of the PhD’s have been moving into tenure track academic positions

within 5-6 years of receiving the PhD.[16] Fuhrman suggests that this branching career pipeline should be supported by changes in graduate training and mentoring to include professional and career development.[16] Through the Broadening Experience in Scientific Training (BEST) grant program that focuses on preparation for careers outside of the traditional academic environment, the National Institutes of Health (NIH) is specifically addressing the issues of the training needs of the biomedical PhD workforce.

At the University of Iowa (UI), approximately 28% of graduate student respondents to our exit survey reported that they did not receive any advice about nonacademic career options from their primary research advisor. This data represents the average over 3 semesters of the exit survey (Spring 2014-15 and Fall 2014). In an effort to begin to address this gap in information, the UI Graduate College developed the "Open Doors Career Education" series for graduate students. Featuring an annual careers conference, networking resources and video podcasts, the Open Doors series is designed to provide students with both face-to-face and virtual opportunities to discover new career paths. The Open Doors conference is an annual event serving over 100 graduate students and featuring UI alumni and other PhDs in non-academic careers. In video podcasts, graduate students can explore careers ranging from teaching at a liberal arts college to doing research in the private sector. Students can join in the conversation live or can view the video

podcasts on the website. In addition to the Open Doors series, the UI Graduate College has organized professionalization across campus based on eight key academic and professional competencies including: 1) Research and Publication; 2) Teaching; 3) Communication; 4) Careers; 5) Diversity; 6) Funding; 7) Leadership; and 8) Wellness. The professional and career development offerings in each of these areas are planned in coordination with UI campus partners, such as the Center for Teaching, the Libraries, and the Department of Rhetoric. The Graduate College serves as the central hub for event promotion.

5. Conclusions

Graduate education is central to the mission of research universities in the U.S. Challenges in graduate education include financial support, diversity and inclusion, career training, and transparency. Recent initiatives across research universities focus on providing graduate students with stable and varied financial support, improving the climate for diversity and inclusion and providing enhanced career services and transparency. Through these innovations in graduate education, the research mission of the university will be strengthened.

Acknowledgements

I would like to acknowledge my University of Iowa Graduate College colleagues for valuable discussions, in particular Associate Provost and Graduate College Dean John C. Keller and Assistant Deans Heidi Arbisi-Kelm and Jennifer Teitle.

References

1. *Public Research Universities: Why They Matter*. American Academy of Arts and Sciences. 2016: Cambridge, MA.
2. *The Path Forward: The Future of Graduate Education in the United States. Report from the Commission on the Future of Graduate Education in the United States*. Council of Graduate Schools and Educational Testing Service. , 2010.
3. Sowell, R.S., T. Zhang, N. Bell, and K. Redd, *Ph.D. Completion and Attrition: Analysis of Baseline Demographic Data from the ph.D. Completion Project*. 2008, Council of Graduate Schools: Washington, DC.
4. *National Science Foundation, National Center for Science and Engineering Statistics. 2015. Doctorate Recipients from U.S. Universities: 2014. Special Report NSF 16-300. Arlington, VA. Available at <http://www.nsf.gov/statistics/2016/nsf16300/>*. 2015.
5. *Pathways Through Graduate School and Into Careers*. Council of Graduate Schools and Educational Testing Service, 2012.
6. Weinberg, B.A., J. Owen-Smith, R.F. Rosen, L. Schwarz, B.M. Allen, R.E. Weiss, and J. Lane, *Science Funding and Short-Term Economic Activity*. Science, 2014. 344(6179): p. 41-43.
7. *Advancing Graduate Education in the Chemical Sciences*. American Chemical Society, 2012.
8. Kent, J.D. and M. McCarthy, *Holistic Review in Graduate Admissions: A Report from the Council of Graduate Schools*. 2016, Council of Graduate Schools: Washington D.C.
9. Page, S.E., *The Difference*. 2007, Princeton, New Jersey: Princeton University Press.
10. Sowell, R., J. Allum, and O. H., *Doctoral Initiative on Minority Attrition and Completion*. 2015, Council of Graduate Schools: Washington, DC.
11. *Revisiting the STEM Workforce (A Companion to Science and Engineering Indicators 2014)*, National Science Foundation. 2015, National Science Board.
12. Zolas, N., N. Goldschlag, R. Jarmin, P. Stephan, J. Owen-Smith, R.F. Rosen, B.M. Allen, B.A. Weinberg, and J.I. Lane, *Wrapping it up in a person: Examining employment and earnings outcomes for Ph.D. recipients*. Science, 2015. 350(6266): p. 1367-1371.
13. Turk-Bicakci, L., A. Berger, and C. Haxton, *The Nonacademic Careers of STEM PhD Holders*. American Institutes for Research, 2014.
14. Wheadon, M. and N. Duval-Coueti, *Student Perspectives on Developing More Relevant PhD Programs in STEM disciplines through Professional Skills Training*, 21st American Society for Engineering Annual Conference and Exposition. 2014. p. 10495.
15. Patel, V., *New Job on Campus: Expanding PhD Career Options*. Chronicle of Higher Education, January 12, 2015.
16. Fuhrmann, C.N., D.G. Halme, P.S. O'Sullivan, and B. Lindstaedt, *Improving Graduate Education to Support a Branching Career Pipeline: Recommendations Based on a Survey of Doctoral Students in the Basic Biomedical Sciences*. CBE-Life Sciences Education, 2011. 10(3): p. 239-249.

Infrastructure Planning and Implementation for Transformative and Incremental Research

**Brian L. Foster, Provost Emeritus, Emeritus Professor of Anthropology
University of Missouri**

A very important element in the planning for research infrastructure is the predictability of infrastructure needs. Research is a creative activity—doing things that have not been done before. Capturing the needs of those who are doing something that has not been done before is a problematic issue, with success depending heavily on the nature of the research being done (NSF. “Academic Research Infrastructure Program: Recovery and Reinvestment (ARI-R2); NSF. FAQs Regarding Academic Infrastructure-Recovery and Reinvestment (ARI-R2). Program Solicitation. NSF 009-562 Part1.www.nsf.gov/pubs/2009/nsf0905.1/nsf09051.jsp). In this paper, I will examine the issues that affect our thinking and action regarding transformative research (i.e. world-changing, very high-impact research) as opposed to more incremental research (i.e., taking the next step beyond what is already known) (NSF. Introduction to Transformative Research. nsf.gov/about/transformative_research/definition.jsp). This complicated dynamic plays out in institutional settings and in higher education broadly as well as other kinds of research venues (e.g., the business world or national labs).

The Idea of Infrastructure

“Research infrastructure” must be defined broadly, including not just STEM research, but also professions, arts and humanities, social science, and more. This paper considers “research” to be creative activity in the broadest sense, and the infrastructure issues have a great deal in common across the many areas of creativity. (For two good examples of the breadth of infrastructure issues see Gisele Yasmeeen, 2015; UMBC, “Research Infrastructure – Center for Innovation, Research, and Creativity in the Arts”.) So, while infrastructure is most commonly thought of as labs, major technology such as a radio-astronomy center, or a nuclear reactor, in this paper it may be a theater venue, a facility to bring together an in-

terdisciplinary group to address fundamental changes in the future of media, or it might include a major fine arts collection or a unique collection of fossils in a museum.

From this perspective, infrastructure includes all of the many resources necessary to support successful research/creative activity. Thus, infrastructure would include personnel—e.g., staff who provide grant support, logistics, lab work, compliance process, stage design, and library circulation. In academic institutions, of course, faculty are a major infrastructure resource (this issue is complex and will be addressed below). Students provide “staff” work in many areas (e.g., in labs, performance venues, media). Facilities (i.e., buildings, lab equipment,

museum collections, and libraries) are core to infrastructure, as are the many IT functions (e.g., communication, data archiving, computational capabilities, and access to prior research results). Many management processes are critical, including a long list of personnel processes (e.g., hiring, P&T, performance evaluations) and compliance management (e.g., IRB, conflict of interest management, export control).

A critical infrastructure element is the network of relationships on which institutional collaborations can be built (e.g., national labs, corporate partners, universities). Similarly, having an effective network of relationships with federal funding sources is critical for certain kinds of research. For example, we need relationships with a broad range of federal agencies, not just NSF and NIH, but also Defense, Homeland Security, Agriculture, Education, and others. This is critical, since most federal funding comes from agencies who do not fund by traditional peer reviewed proposals. And, along this same line, relations with beltway bandits, lobbyists, and other “highly connected” people in Washington, D.C. are an important element of infrastructure. And then, for public institutions, there is the funding from states and/or other governmental sources. Of course much research is funded by the institution or, if grant funded, much is significantly subsidized.

A key element of infrastructure planning is that all of these elements intersect with others. And to make matters even more complex, there are widely varying needs across disciplines, professional schools, in basic versus applied research, and discipline-based versus interdiscipli-

nary or multidisciplinary research. In addition, there is the nature of the institution (e.g., the strengths that it’s recognized for, the brand), and the nature and amount of its funding (e.g., public or private, degree of state support, endowment, fundraising, etc.). And finally there is the complication that research/creative activity is about creating new “knowledge” (in the broadest possible sense of the word), and the content of research and needed infrastructure is constantly changing due to changes brought about by the research itself.

The complexity of this broad perspective on research infrastructure is made even more daunting by the fact that higher education is in a time of great volatility in many dimensions: state funding, demographic changes, international competition, political interest and intervention at all levels, decreases in federal grant funding, and a significant loss of confidence/respect for higher education in the general public—a critical issue for political impact.

Transformative and Incremental Research

An interesting conundrum for Universities is to think about the relative value, priority, and feasibility of transformative, very high-impact research compared with more incremental work that extends what is already known. NSF defines “transformative” research as follows:

Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice or leads to the creation of a new

paradigm or field of sciences, engineering, or education. Such research challenges current understanding or provides pathways to new frontiers (NSF, “Definition of Transformative Research”).

This definition could be extended to other than STEM areas, including humanities, social sciences, professions, biomedical research, performing arts, and much more (Wikipedia “Transformative Research”). It is important to note that the idea of “transformative” research is often seen as converging with what is called “high impact research” (American University, 2015), and that the latter is commonly seen more as applied than basic research (Economic and Social Research Council).

There is, of course, a continuum between extremely “out of the box” transformative research and very structured incremental research. Research at both ends of the continuum is extremely important—but important in different ways. The biggest, world-changing results lead to more incremental research, often very important at both ends of the basic and applied research continuum. As the NSF paper on transformative research notes: “History shows that it is difficult to predict which research projects will result in transformative results before the research is conducted and the scientific community has assimilated the findings.” (NSF. “Transformative Research: Challenges of Identifying Potentially Transformative Research” p. 1). This assimilation may take decades (Sabine Hossenfelder, blog post, BackReaction.2012, p. 1). On the other hand, very high impact, ground-breaking outcomes

can arise serendipitously from surprise results on more structured incremental research.

Transformative research generally builds on a different mindset than more incremental work. Moreover, the incentives and disincentives that researchers encounter are profound, given the differences in predictability, outcomes, and the time frame (we will return to these issues in different contexts). Long-term collaborative relations with external entities such as national labs, corporate partners, or other universities tend to be more common for the more transformative, long-term research. But many infrastructure issues such as facilities, a broad range of institutional support (staff, compliance) are pretty much the same for both transformative and incremental work. From the standpoint of institutional stature, the transformative results generally bring the most recognition and honor. That said, many researchers, political constituents, and others—especially those on the applied research end—are more interested in results of immediate practical significance, whether in STEM areas, social sciences, humanities, professions, or arts. In fact, as noted above, this “practical” or “applied” outcome is how many would define “high impact” research. Clearly, a balance must be defined in institutional mission, planning, and broader campus culture, which in turn need to be aligned with critical elements of the campus environment such as incentive/disincentive structures (e.g., P&T), physical infrastructure, staff, and potential external collaborations.

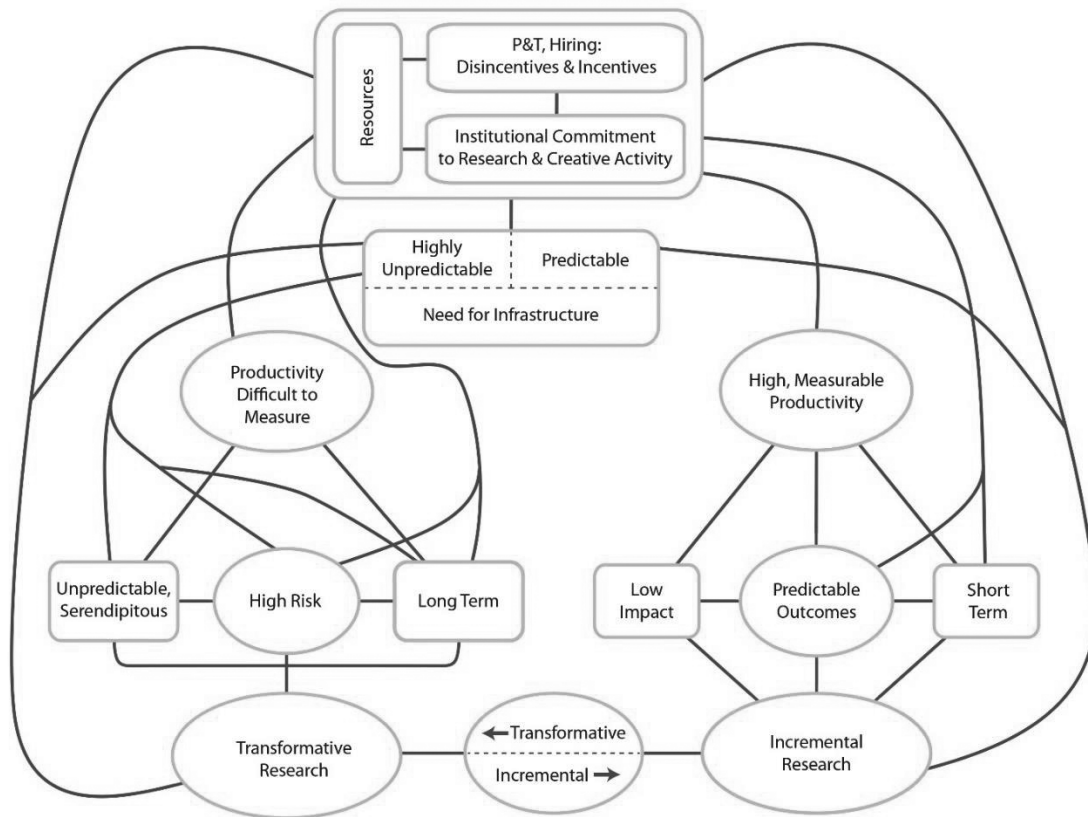
How it All Fits Together In the Perspective of Infrastructure

Figure 1 provides a simplistic, though still complicated, picture of the dynamics underlying the complexity of the infrastructure needs and the research priorities (transformative or incremental) of an institution.

One can start from either the top or the bottom of this figure, but here we will start from the bottom. The most important observations are that Transformative Research is extremely “high risk” with respect to the probability of achiev-

ing a positive outcome, while incremental research is far more predictable, both in implementation and in results. As noted on page 2, there is a continuum between transformative and incremental research—elements to the left of the middle in Figure 1 leaning toward transformative research, and to the right leaning toward incremental research. This continuum has a complicated set of implications for the rest of the analysis. It is important to note that some transformative research is extraordinarily demanding for infrastructure (e.g., facilities, instrumentation,

Figure 1. Institutional Implications of Transformative and Incremental Research



staff), while other work may simply be done in a researcher's existing lab or performance venue without additional resources.

Returning to Figure 1, on the transformative side, "high risk" implies both highly unpredictable, even serendipitous, and very long-term outcomes (NSF, "Challenges of Identifying Potentially Transformative Research"). Incremental research, on the other hand, suggests more predictable and short-term outcomes, though at the "incremental" end of the continuum, much lower impact. The idea of "productivity," which is central to accountability, setting priorities, and many other issues, is highly problematic on the "transformative" side, since it is very difficult to measure something that has never been done before and often challenges what is known. On the "incremental" side it is fairly predictable and measurable, since it is building on what is already known.

So, the question is, how does all of this play out from the perspective of research infrastructure? This raises a new dimension of complexity, since the broad campus culture of universities comes into play, including such things as hiring, fiscal resources, and priorities. In addition, there is the influence of constituencies as diverse as political, donor, trustee, students, and parents, as well as corporate and community elements, many of whom have conflicting interests. Some of the most critical effects on research arise from the incentives and disincentives posed by the promotion and tenure (P&T) and hiring processes. For associate and especially assistant professors, who

will be facing promotion and tenure hurdles: P&T, as practiced in most institutions, provides a strong disincentive for pursuing long-term, unpredictable research projects (Foster 2016). Since the likely long-term projects would not provide the kind of productivity needed for promotion or tenure, junior faculty are likely to go with more structured incremental research, which is more likely to produce the necessary publications, citations, and other elements of productivity needed for tenure or promotion within the probationary period. When it comes to infrastructure, the institution is not likely to invest significantly in a junior faculty member's transformative project, given that the researcher is unlikely to remain at the university—the likely case being that he/she won't receive tenure or promotion, thus making the infrastructure investment extremely risky.

Even full professors with tenure face significant disincentives for undertaking research toward the transformative end of the continuum, given that outcomes are extremely difficult to define and to present as credible, and "selling" the project to the institution or to a funding agency is at best difficult. A multi-year demanding project is likely to mean few publications or other relevant kinds of productivity (depending on the discipline, profession, etc.), thus compromising the researcher's status, and compromising his/her ability to write credible grant proposals, sell the project to the university for funding, or otherwise find facilities, equipment, and other resources needed to move the project forward.

Looking at these issues from the other side: there are strong incentives for the University to encourage short-term, more predictable incremental research, for which institutional funding can be allocated with a reasonable degree of risk, for which funding agencies are more likely to be positive and award grants, and which will result in research productivity (e.g., grants, publications, citations) that affect rankings for the institution and recognition for the researcher. From the infrastructure point of view, the needed resources are likely to be mitigated by grants, and the institutional capacity for funding infrastructure needs will be assessable such that priorities can be assigned based on somewhat predictable needs and outcomes.

If the institution's capacity (people, facilities, necessary support processes) is adequate to provide sound support for a wide range and large amount of incremental research without a significant amount of flexible funds for a costly, risky, high-impact, unpredictable project, it is unlikely that transformative projects will get high priority. Other paths may exist with modest institutional investment—e.g., funding from a major donor, foundation, or governmental agency with a special interest in the area of the project—but receiving such funding would require other kinds of resources in development, government relations, and corporate relations. Corporate collaboration or funding may be another path.

For an institution with a very large resource base, the situation is, of course, very different with respect to its ability to provide substantial funding. Moreover, it is such institutions who have the broad, effective networks of relations with

wealthy donors, potential corporate collaborators, and with federal agencies that provide the majority of federal research funding through processes other than traditional peer-reviewed grants from NIH and NSF. In addition, such institutions—generally elite research universities—hire senior faculty with tenure who are already well positioned in the academic world, who will not face the challenges and special incentives/disincentives of promotion and tenure, and who could be hired precisely to do very high-impact/transformational research that is already on the researcher's radar.

It is important here to return to the idea of the continuum between transformational and incremental research. The work somewhere in the middle of the transformational/incremental continuum tweaks all of the issues considered above. The outcomes may be much more predictable than the far-end transformational, thus making the project more likely to get grants, to bring outcomes in the short term, to perhaps have relatively short-term applications, and to fit into existing facilities. In addition, the shorter term, more predictable outcomes mitigate the threat to promotion and perhaps even tenure. Thus at the center of the continuum, the limits on traditional productivity are less than at the transformational end. But as compared to the incremental end, the "center" still poses disincentives through processes for promotion, compensation increases, and other benefits of high productivity—issues of significant consideration for researchers.

How It Plays Out in Different Academic Areas and Institutional Environments

Given the broad perspective on infrastructure outlined on pages 75-77, high-

level infrastructure is likely to be in areas of special institutional strength. This is an effective strategy for having not just incremental research done, but also presents potential for hiring high-quality faculty who are doing transformative work and who need special infrastructure. Such areas of strength may be historical accidents; some may be the outcome of a major gift from a wealthy donor with a passion for the area and a connection to the institution. Some strengths may come from an institutional investment (e.g., a bond-funded facility) in an area that is promising because of the location of the institution (e.g., new major corporate partners in the area or being embedded in a special environmental location). And there is the possibility of a faculty member, alumni, or external partner setting up a for-profit technical service provider that could serve researchers in a very broad area—even internationally. These are all, of course, randomly chosen examples to illustrate the range of influences on funding for high-level infrastructure.

Rather than attempt to frame a range of abstract examples, I will move on to several major facilities and other assets of the University of Missouri (MU) to try to enrich the argument. MU has some stunning strengths that are related strongly to unique facilities and other assets that support both the incremental research and provide the recruitment opportunities to bring to MU those interested in transformative research in these areas. Information on all of these initiatives can be found on the MU website (Missouri.edu).

There are, of course, significant differences across disciplines and different

funding strategies for dealing with infrastructure issues for transformative research. To explore some of these issues, I turn now to five different initiatives at the University of Missouri in Columbia. The five “approaches” are very different: a very strong nuclear reactor, a research center closely linked to the functions of the reactor, an interdisciplinary group that does research and clinical services for those on the autism spectrum, an institute that deals with research on the future of “journalism,” and a creative facility for independent senior living that has become a national model. In addition, I’ll briefly discuss a new initiative that was funded by a large gift from a passionate alum; its focus on issues of democracy, and it is anchored primarily in the humanities and social sciences.

MURR (MU Research Reactor). Perhaps the most impressive resource for transformative research at the University of Missouri is the Research Reactor, which was established approximately fifty years ago under the leadership of President Elmer Ellis. This was a vision of an iconic leader, based on the idea that nuclear research would be a central element of the U.S. future. The fiscal, regulatory, and research vision were all extremely complex and difficult to implement, but Ellis made it happen. A significant side-bar for this facility is that it is a major producer of radiopharmaceuticals, which produce significant revenue for the facility. Today MURR is the nation’s most powerful research reactor on a university campus.

International Institute of Nano and Molecular Medicine. Accordingly, MURR has become a significant research asset for MU—one of the most important

cases of which was its role in recruiting a faculty member who had a potentially transformative research agenda in Boron Chemistry (the end of which is still to be determined after approximately eight years at MU). The Institute was established as part of the recruitment of Fred Hawthorne, a member of the National Academy of Sciences and nominee for the Nobel Prize. The investment was significant: construction of a new building (several million dollars) near the reactor, and support for several support staff/faculty who came to MU with Dr. Hawthorne. There was no assurance that the Boron Chemistry research would produce the kind of targeted cancer treatment that was the vision for the program, but Dr. Hawthorne's status as a researcher and progress to date on the project were considered solid justification for the extremely significant investment. As is the case for all such transformative research, a successful outcome was not (and still is not) certain, but clinical trials are now underway. The point, of course, is not that it was a bad investment; rather, it was as good an investment as can be imagined for a truly transformative research initiative...an investment that would have been impossible without the earlier investment in a uniquely valuable resource—the research reactor.

Reynolds Journalism Institute. Another somewhat similar development, though in a field very different from nuclear science, is the foundation of the Reynolds Journalism Institute (RJI), which was built on the foundation of MU's School of Journalism—the oldest and arguably the most distinguished Journalism school in the world. In 2004 the Reynolds Foundation, established by

an extremely successful alum of the School of Journalism, provided a gift of \$31 million to establish the RJI. Major renovation of an iconic building next to the School of Journalism was done to provide perfect space for the journalism research enterprise. The launch of the Institute was extremely successful, and in 2012 the Reynolds Foundation provided another gift of \$30 million to endow the operations of the RJI. The RJI is now a powerful complement to the highly regarded School of Journalism, having supported the startup of several significant enterprises, supported research on the future of media (an extremely volatile and socially important element of American society) and a significant asset for the stature of the University of Missouri.

The Thompson Center for Autism and Neurodevelopmental Disorders. A very different initiative was establishment of the Thompson Center, which built on the rather scattered assets in many departments/colleges regarding Autism and other neurodevelopmental disorders—units as diverse as College of Education, Early Childhood Education (School of Human Environmental Sciences), Psychology, Pediatrics, Psychiatry, Clinical Psychology, Health Psychology (the department of the founding director), Sociology, Social Work, and even Athletics. With the support of the Thompson Center, the interdisciplinary community came together to create a nationally prominent center for research and clinical services for people on the autism spectrum. The Center has moved from a very marginal physical location to its own building near the MU Women's and Children's Hospital, and it is now

building a significant addition to its already impressive facility. As was the case for the RJI, the Thompson Center was driven by the passion and insight of an MU alum, but it was not built on the foundation of an integrated existing program or center in the area of Autism.

TigerPlace. TigerPlace is an innovative home for independent senior living. It was developed by the School of Nursing with collaborations from engineering and other disciplines as part of a broader project on aging in place. One of the distinguishing features is that it includes very sophisticated technologies for tracking the residents, detecting falls, and creating sophisticated longitudinal data bases on residents' patterns of life—a unique research asset. The technology was created jointly by Nursing and Engineering. The facility was built by Americare Corporation, a large healthcare company from Sikeston, MO, working closely with Nursing; today TigerPlace is owned and managed by Americare. It has received a great deal of notice nationally as a model for such facilities, and several very positive things have followed. One is creation of an affiliated Nursing Home facility, the Neighborhoods, which is located very close by. Marilyn Rantz, the leading nurse for the creation of TigerPlace was elected to the Institute of Medicine, and recently the Nursing School received a grant for more than \$20 million to develop facilities in the St. Louis area.

Kinder Institute on Constitutional Democracy. A very different kind of initiative is the Kinder Institute (formerly the Kinder Forum), which was given important momentum in 2016 when it re-

ceived a \$25 million gift to endow the operation of the center, which is focused on education and research on the U.S. Constitution and on American democracy in history, theory, and practice. The Institute was initially based in the History and Political Science departments, but it has incorporated faculty from other departments and is now a truly interdisciplinary center which has a physical home. The goal is for MU to become a national leader in research and education in the area of constitutional democracy, recruit prominent scholars, and support both research and educational activities. The Institute is new, and its mission is still somewhat unclear, but it builds on significant strengths at MU and has potential to support transformative research and educational practice. It has been driven significantly by the passion of Rich and Nancy Kinder and their strong relations with MU. Clearly, it is an initiative with significant potential to be far toward the transformative end of the continuum.

The question, now, is how these six “initiatives” relate to developing infrastructure for transformative research. First, all but one have had significant external funding for establishing the initiative. The one that was not externally funded was the International Institute of Nano and Molecular Medicine, for which a very significant institutional investment was made explicitly to bring a prominent internationally recognized researcher to campus to continue a potentially transformative research program—an investment that included building a new building near MURR to house the Institute. But what made the recruitment of Dr. Hawthorne possible was the presence

of a unique facility, MURR, and the interdisciplinary cluster of researchers working with the reactor on nano science, radiopharmaceuticals, and other activities related to his boron chemistry research.

From this perspective, MURR is a unique facility that has potential for supporting transformative research. It was not established with a specific research plan in place, though it has seen remarkable successes in research, radiopharmaceutical production, archaeometry, and much more. What is perhaps most surprising is that the campus has not developed a broad, coherent, interdisciplinary program in Nuclear Science and Engineering, though there are very significant strengths across campus, including the Nuclear Science and Engineering Program (a highly productive program of four engineers), radiochemistry, radiology, and a nuclear engineering group in the College of Engineering.

As noted earlier, the gift for the Reynolds Journalism Institute is building on a campus resource rather analogous to the reactor: the MU School of Journalism is internationally recognized as one of the most prominent journalism schools in the world. In this case, MU is building not on recruiting a world-prominent researcher with a particular on-going program, but is building on a distinguished, internationally recognized group of faculty known for being “out-front” in the incredibly volatile world of journalism. RJI has helped bring together researchers across campus with related interests (from policy studies, business, creative writing, communication studies, and much more) and has been an important factor in attracting new faculty to the School of Journalism and RJI. It is fair to

say that the RJI has already had very significant impact in the world of media, including research, start-up firms, and student experience. There is real progress across the continuum from incremental to genuine transformative research.

The Thompson Center was built on a substantial gift from alumni with a strong connection with the University of Missouri. The vision and passion for the Thompson Center stemmed from a family connection with autism. MU had significant assets (especially faculty), but they were scattered across the campus. Building on MU’s strong interdisciplinary culture, foundation of the Center brought this broad group together more formally, creating a center unlike other autism units across the country, the strong and broad interdisciplinary collaboration in research and clinical services for autistic children being especially unique. The potential is very strong, and the infrastructure (physical facilities, people, grants, and now nation-wide recognition) has significantly advanced the Center on the path to transformative research and clinical service.

TigerPlace has a very different kind of development. The “Aging in Place” concept was developed in the School of Nursing, and an institute was created that engaged a number of Missouri senior living institutions in providing an innovative kind of environment for seniors who were able to be “independent” but with very specific kinds of support. The idea of TigerPlace grew out of this senior living idea, with significant collaboration between the School of Nursing and the College of Engineering. As noted above, implementation of the idea was done in collaboration with Americare, a large

senior living corporation, which actually built TigerPlace and manages it, but very much driven by the concepts that came from Nursing and Engineering—a perfect model for corporate and university collaboration.

Finally, the Kinder Institute is a different kind of initiative, founded on several years of dialogue with the donor about the potential for an institute that would build on MU's strengths in Political Science, History, and the Humanities. The \$25 million gift to endow the Kinder Institute on Constitutional Democracy builds on significant strengths in social sciences and humanities, but also Law, Policy, and other areas. The mission is to support research and education on the U.S. Constitution and American democracy in history, theory, and practice. The Institute will be located in the iconic Jesse Hall. As Director Justin Dyer has said, it's important to have an actual physical home for the center where scholars and students from different parts of the campus can come together "all in one place." The funds will support faculty fellows, faculty hiring, program development, guest lecturers, and other activities that contribute to the stature and impact of the center's work. The Kinder Institute doesn't have an anchor like MURR or the Journalism School. More like the Thompson Center, it builds on significant strengths and brings them together in a way that provides potential for very high impact research. But the plan is new and is a work in progress.

Concluding Thoughts

All of the six initiatives described above have potential, five having moved far along the transformative research continuum. At least one of them is on a

direct, well-defined track to transformative cancer treatment. Closely related is an internationally valuable research resource, MURR, which is a critical foundation for the Hawthorne Center. Three of the other centers have already achieved significant national and international recognition: the Thompson Center, the RJI, and TigerPlace. It may be a little too far to claim that they have achieved "transformative" research results, but they are all quite a way down the continuum from incremental to transformative—well beyond the "center" as represented in Figure 1.

What is perhaps more important is the broad range of contributions these highly successful initiatives have produced. One is a combination of research and clinical services (i.e., the Thompson Center)—very significant contributions in both dimensions. One builds on an internationally famous journalism program to provide out-front research and education related to the extremely volatile world of media—a program with immense potential for strong influence in a critically important area of today's political, social, intellectual, and economic dynamics. One—TigerPlace—builds on dynamics in the extremely important area of healthcare and quality of life in a world where life expectancy has increased dramatically. The potential impact of this model of senior living is significantly far on the "incremental/transformative continuum," as discussed above. And then there is the Kinder Institute, which addresses one of the most critical issues of our time. Its focus is the place of American democracy in a world with many challenges to the very idea of democracy (e.g., religion, economic success, and

global positioning)—all raising questions about the somewhat naïve American idea that its democratic history “should be” a model for the rest of the world.

In all of these cases, infrastructure has been a key element of their success/promise. The many relevant infrastructure elements include physical facilities in all cases, leadership, faculty and other key personnel elements, fundraising resources, campus culture (e.g., interdisciplinary collaboration), political positioning, networking across higher education and beyond, and much more. On the one hand, these very significant initiatives would not have come to where they are without significant infrastructure (physical, personnel, etc.), and on the other hand, they would not have achieved the necessary infrastructure without VERY significant external resources or, in the one case, the strong institutional commitment to move forward with an opportunity to bring a transformative research program to the University (based, of course, on the presence of a unique and relevant resource—i.e., MURR).

References

1. American University. “Final Report: Task Force on High Impact Research.” May 26, 2015.
2. Economic and Social Research Council. “What is Impact?” www.esrc.ac.uk/research/evaluation-and-impact/what-is-impact/
3. Foster, Brian. “Promotion and Tenure Rituals: Where they have Taken Us, and Where We Are Going.” Vancouver, B.C.: Society for Applied Anthropology Annual Meeting, April, 2016.
4. Hossenfelder, Sabine. “What is transformative research and why do we need it?” backreaction.blogspot.com/2012/08/what-is-transformative-research-and-why.html
5. NSF. Introduction to Transformative Research. nsf.gov/about/transformative_research/definition.jsp
6. NSF. “Challenges of Identifying Potentially Transformative Research.” nsf.gov/about/transformative_research/challenges.jsp
7. NSF. Academic Research Infrastructure Program: Recovery and Reinvestment (ARI-R2). www.nsf.gov/od/oia/programs/ari/
8. NSF. “Definition of Transformative Research.” www.nsf.gov/about/transformative_research/definition.jsp
9. NSF. FAQs Regarding Academic Research Infrastructure-Recovery and Reinvestment (ARI-R2) Program Solicitation. NSF 009-562 – Part 1 www.nsf.gov/pubs/2009/nsf09051/nsf09051.jsp
10. UMBC. “UMBC50: Research Infrastructure.” Circa.umbc.edu/files/2013/10/Live-wire6-MicrokingdomCrop.jpg
11. Wikipedia. “Transformative Research.” en.wikipedia.org/wiki/Transformative_Research
12. Yasmeen, Gisele, “Social Science Infrastructure: North America (Research and Teaching). International Encyclopedia of the Social and Behavioral Sciences, 2nd edition, Volume 22. Elsevier, 2015. Pp. 593-603.

Seed Funding Programs in a Comprehensive Liberal Arts and Sciences College

Carl W. Lejuez, Dean, College of Liberal Arts & Sciences, University of Kansas

Jessica Beeson, Director of Research and Engagement, College of Liberal Arts & Sciences, University of Kansas

Maureen Cole, Assistant Director of Research and Engagement, College of Liberal Arts & Sciences, University of Kansas

Seed funding is crucial to the success and growth of a college of liberal arts and sciences. The current paper outlines common and unique features of seed programs within and across Universities, reviews a case study from the college of behavioral and social sciences (BSOS) at the University of Maryland, and discusses key considerations in implementing a seed program within a college of liberal arts and sciences.

Overview

The current manuscript provides an overview of seed funding and discusses the rationale for such programs as well as the details in their construction and execution. The information included here is based on data and approaches pulled from available online resources, publications from groups such as the National Leadership Council, and a survey of college deans (see below for details). Additionally, we highlight results of the University of Maryland Dean's Research Initiative in the College of Behavioral and Social Sciences, which was directed by the first author in his previous role as associate dean for research.

To provide specifics on our survey to address how seed funding is undertaken at comparable institutions, we contacted 10 deans from geographical and mission-similar universities with a single comprehensive college of liberal arts and sci-

ences or arts and sciences. Questions focused on whether their college offered seed grant funding, size of awards offered, measurement of success, impact of the funding, and their reflections on these programs. Eight of the 10 deans that we contacted responded, and half of those indicated that their College offered seed grant funding. Of those that did not, the availability of funds through central university offices and seed funds not being viewed as a good use of limited budget were cited as the top reasons why they did not offer seed funds for research.

Common Features of a Seed Funding Program

Goals and Benefits

Seed funding programs provide a tool to support emerging, cross-campus research strengths that exist and fit into campus mission/goals. They can be targeted to and facilitate the impact of strategic goals of a college and the campus

more broadly. Seed funding programs send an important message about research value and can be used to stimulate productivity (grants, intellectual products, student experience). These programs can be focused on proactive efforts but also can be crucial for providing a bridge for productive and previously funded researchers through lean times.

Our survey indicated the most common rationale for seed funding was for building interdisciplinary bridges, particularly when the work may not be ready for funding from federal agencies particularly in the case where the work is sufficiently new and may push the boundaries of those providing peer review. These interdisciplinary applications across units (often referred to as Collaboratories or Colaboratories) were also reported to provide a strong return on investment. Next most common was the funding of small and medium sized grants to a single investigator, as well as bridge funding. Most but not all programs provided priority to junior investigators. While most programs allowed funding to faculty to graduate students, few programs offered seed funding directly to graduate students for their research.

Not surprisingly, seed funding programs were reported in our survey to have an important impact on faculty morale. However, it was also noted that the competitive aspect that comes in the likely case where there isn't sufficient funding for all projects can also negatively impact morale in at least a small subset of faculty.

Notably, our survey indicated a greater focus on the sciences and less

clarity in terms of the role of seed funding for the arts and humanities. Seed funding for disciplines in the arts and humanities have unique challenges and opportunities. Often faculty in these disciplines look to seed funding to support one-off intellectual projects such as completing a book or creating a piece of art that may not take the same step-wise format that many seed funded projects in the sciences take. While these projects may not generate larger external funding, they do contribute to the larger body of research and the status of the college. Arts and humanities faculty strengthen interdisciplinary, multi-unit projects involving faculty from the natural and social sciences. Examples of this can be found in large-scale research projects around themes such as migration, environmental sustainability and human trafficking, to name a few. Arts and humanities departments tend to have larger teaching loads than their counterparts in other disciplines, making funding teaching releases for faculty participating in the above research projects a particularly attractive option for the use of seed funds. To address the issue of equitable distribution of funds across disciplines, a few deans in our survey indicated offering separate allocations for different divisions to ensure sufficient support for the art and humanities.

Use of funds

Similar to the variability of the types of projects seed funding supports, there is considerable diversity in how funds are allocated to these projects. In our survey and other research, we found that there does not seem to be a gold standard in regards to the budget criteria. Some programs focus funds on

equipment and costs associated with gaining pilot data, including research related travel, while others focus on “opportunity costs” such as course release time or summer salary. The scale of the project as well as the discipline of the faculty member often dictate what items are included on the budget.

Our survey indicated travel, pilot data, and equipment costs as the most common allowable uses of funds followed by course releases and summer salary. There are also examples of seed funds where special criteria are laid out by the unit with the call for applications. For example, in some cases there is a clear requirement that projects must articulate direct benefits to students; requiring that the narrative and budget materials must clearly define the number of students who will be impacted by this project and how they will be impacted (internships, course development, scholarships, lab experience, etc.). While less common, some programs focus on community-engaged scholarship and thus the funds may support software, program evaluation, or infrastructure needs of the community partner.

Our findings indicate that there is not one common way to administer a seed fund program. The success of a program will have many variables at specific institutions that can include aligning the project with the mission of the college or university, the needs of the discipline applying for the fund, the scale of the amount awarded, and the metrics put in place to measure success.

UMD Case Study

Prior to 2010, there was very limited seed funding available in the college of behavioral and social sciences (BSOS) at

the University of Maryland. There was campus level funding but for a small unit in the behavioral and social sciences, it was difficult to compete very effectively for sufficient funds that often were directed towards the natural sciences and engineering. To address the lack of research seed funding for the college, the dean negotiated a targeted investment from the campus for college-specific seed funding. The initial year of the program began with a relatively large infusion of funds of about \$600k and was set to about \$200-250k in subsequent years.

Program Development

As shown in the Figure below, the program had a positive impact on research funding in the college in its first two years and it certainly positively impacted morale. However, the program lacked structure and clear strategic direction and the first author of this manuscript was charged by the dean for his incoming role as associate dean for research to revamp the program to strengthen and clarify goals, categories and allocation, selection process, metrics, and reporting and evaluation.

Goals

The BSOS seed funding program was revamped to start with the strategic planning happening in the College and to focus its goals on supporting that planning. This included strategies to increase overall grant productivity, but it also included a focus on interdisciplinary research, graduate student grant writing, and expanded research opportunities for undergraduate students working in teams with faculty. Finally, it also was viewed as an approach to support individual researchers with a focus on junior investigators as well as more senior investigators with a

track record of funding who now needed support following a lapse in funding. Along these lines, funding also was used to support a larger program that had lost federal funding and was exploring other larger scale funding options (ADVANCE program funded by NSF).

Funding Categories and Allocation

A wide range of award categories were included with a focus on tying the categories to explicit strategic goals of the College. The following Table outlines these categories.

Category	Goal	Requirements
Collaboratory \$30,000 for each award	To promote high impact cross-cutting ideas to spark trans-disciplinary research in BSOS. Funds support the formation of interdisciplinary research teams with resources to develop ideas, conduct research, and seed larger scale projects.	Proposals must include at least two faculty members and at least two different departments within BSOS, additional collaborators are encouraged from across and outside of campus (national and international).
Level 1 Seed Projects \$10,000 for each award	Support scholarly research projects with a well-defined set of aims and methods, with the specific purpose of “seeding” future external funding applications.	Awards can be used to support a currently unfunded project or a partially/fully funded project that could be expanded significantly with additional funds.
Level 2 Seed Projects \$20,000 for each award	Support scholarly research projects with a well-defined set of aims and methods, with the specific purpose of “seeding” future external funding applications.	
BSOS ADVANCE Scholars \$10,000 for each award	The BSOS ADVANCE Scholar Award will support a junior scientist who will serve as Principal Investigator and a senior scientist who will serve as Co-Investigator/Mentor.	Principal Investigator must be a woman and be at the rank of Assistant Professor. The senior scientist also must be a woman and rank beyond Assistant Professor.

Category	Goal	Requirements
Post Start-up Research Support \$10,000 for each award	To support research activities after traditional start-up packages end. Focuses on a project that can be developed further into an external funding proposal.	Must be in years 4-6 of initial appointment at UMCP.
Master's Thesis / Pre-candidacy Research \$1,500 for each award	To support Master's Thesis or comparable Pre-candidacy Research expenditures (e.g., participant payment, travel costs, conference fees). Funds cannot be used to supplement stipends.	Must be in good standing in their program, in their first 3 years since entry into the program, and yet to complete the thesis project.
Doctoral Dissertation Research \$2,500 for each award	Supports support Doctoral Dissertation research expenditures (e.g., participant payment, travel costs, conference fees). Funds cannot be used to supplement stipends.	Must be in good standing in their program, have advanced to candidacy, in their first 6 years since entry into the program, and yet to complete the dissertation project.
BSOS Summer Scholars \$3,000 for each award	Supports undergraduate students independent research projects in the summer. Students may expand their research into an independent study or Honors thesis during following fall semester.	BSOS Summer Scholar proposals are jointly submitted by the undergraduate student and the faculty mentor who provides a support letter.
Mentored Undergraduate Research Teams \$2,500 for each award	To support creative efforts to provide outstanding undergraduate research experiences to a small group of undergraduates.	Students should be BSOS majors unless the application includes a clear statement arguing for the value of targeting students outside of BSOS.

Selection Process and Criteria

To provide as fair and equitable of a selection process, the BSOS brought together one faculty member from each of

its 10 departments. The faculty member in a particular department served as the lead reviewer for each grant from their department (unless there was a conflict of

interest) but all committee members voted on each application (modeled off the NIH grant review approach). Unlike tenure review where departmental colleagues often are recused, there was concern that the level of expertise needed to evaluate the proposals would be insufficient if the departmental representative was recused. It is notable that even with ensuring representation from all 10 departments, it was clear that the level of specificity and disciplinary knowledge needed to evaluate these proposals equitably was challenging. Anecdotally, it appeared that having someone closely tied to your discipline not only didn't provide an advantage, but there appeared to be significantly higher standards in reviews from those individuals.

Metrics

The metrics on which an application is funded is central to the success of the program. From our survey of other deans, most reported that the quality of the current idea was more important for funding. We aimed to place as much focus on outcomes as the merit of the idea itself. We also were sure to align the metrics with the larger strategic goals of the college. The guidelines for metrics were constructed to emphasize these issues and are reflected below.

In addition to the intellectual merit of the proposal, preference will be given to applications that: a) show previous efforts to obtain external funding; b) provide a detailed plan for meaningful outcomes resulting from the seed award with a timeline of measureable outcomes that include research activities, funding efforts, and scholarly products; c) provide support for students from un-

derrepresented groups; and d) propose particularly efficient use of funds and smaller budgets as appropriate.

Asking faculty at the start of the process to focus as much on the products of the funding as the idea itself was challenging for some group members at the start of the process, though there was acknowledgement by the end of the process that this approach was a bit more objective.

Reporting and Evaluation

Outlining metrics is a crucial step in building a seed program, but these metrics aren't relevant if the proper reporting and evaluation process isn't in place. It was our experience at the start of the BSOS program at UMD that while significant energy would go into choosing the most meritorious applications, little emphasis was provided for reporting from the investigators on outcomes as well as overall program evaluation from the dean's office. Of note, in the initial years of the program, the reporting occurred upon the end of the funding period. In most cases, this wasn't a sufficient time for the likely outcomes to have come to fruition and the reporting indicated most often that progress was ongoing. This made any real evaluation quite limited. Outcomes were tracked over time to establish success but there was no sense of accountability in cases where outcomes weren't achieved.

We instituted several strategies to provide a clearer focus on achieving the stated outcomes, which is particularly relevant to the extent that the emphasis on proposed outcomes in the stated criteria for funding decisions. As noted below, we instituted a progress report

9 months into the 12-month funding. This allowed for the evaluation of outcomes that were proposed mid project and served as a reminder to recipients of the impending final report. That final report was extended out a full 9 months after the end of the project (at 21 months). This timeline was chosen to provide sufficient time for proposed outcomes to come to fruition (and be reported on) and to coincide with the proposal evaluation for the next year of seed funding. The guidelines for reporting and evaluation were constructed to emphasize these issues and are reflected below.

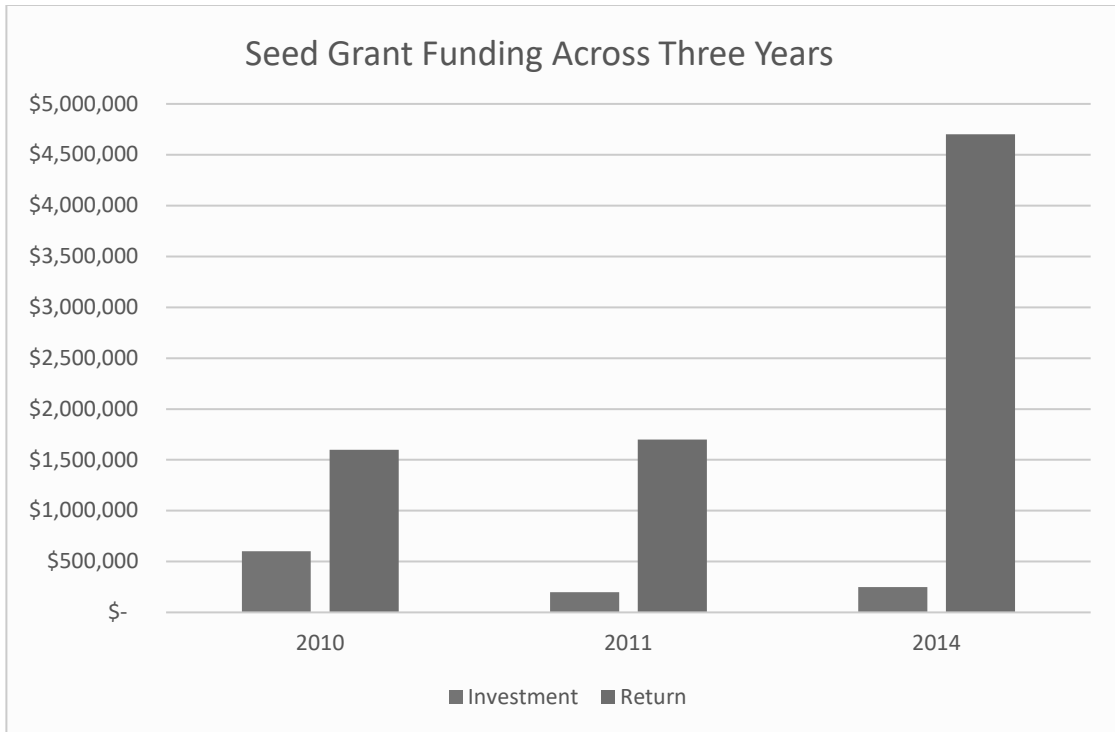
Acceptance of funds acknowledges your willingness to provide a one-page progress report at 9 months and again at 21 months, and to attend a meeting of seed funding recipients to present progress at these same time points. Please note that research funding must be spent in the first year (carry-over is not permitted) but there is an expectation of continued progress from the project at least through a second year. Progress reports will include the initial proposed timelines and actual progress for research activities, funding efforts, and scholarly products. Where a disparity exists, a plan for addressing this disparity going forward must be proposed.

For the timeline referenced in b) above, greater detail will increase odds of seed funding and should include target funding agencies and deadlines for applications as well as possible publication outlets and submissions timelines for the products. Specific details of actual productivity may vary from what is proposed (submission to Journal X instead of Journal Y, or grant submissions in June and October instead of February and June) but the overall scope should be consistent.

Results/lessons learned

The results of the program as a function of grant dollars awarded for a given year of seed funding are provided in the figure below. As can be seen the return on investment indicated the value of the program in the initial two years, but clearly the increased focus on goals, categories and allocation, selection process, metrics, and reporting and evaluation in the third year had a dramatic impact on return.

It is important to note that return on investment is challenging to interpret with full clarity. Indeed, it is difficult to determine with any certainty that a particular successful grant would not have happened at all or with the level of success if seed funding wasn't available. The results here when considered across years provide are quite meaningful in suggesting the importance of the added focus across years, but the larger point of clearly establishing impact of a seed grant is challenging. It is also notable that return on investment as measured here requires an appreciation for the fact that the investor is largely not the one reaping the financial rewards. It is true that a share of indirect costs is returned to the college which can offset some of the costs, but this investment is best conceptualized with the return considered in terms of research output, staff and students hired and getting significant development experiences, and the overall prestige of the unit. This of course has many benefits, but it is not in the same currency as the investment, which may be more relevant in difficult financial times.



Building a Seed Program from the Ground

There are many useful lessons that emerge from the survey of deans, the results of the BSOS program, the goal of being strategic with seed funding, and the complexities of addressing the full range and needs of a comprehensive liberal arts and sciences college. In a time of uncertain budgets, efforts to develop seed programs must consider creative strategies raising the necessary funds. Research funding may not always be the first thing on the minds of endowment officers and potential funders, and therefore it is important to be able to tell the story of the full impact of research.

Being able to articulate how research builds the prestige of the institution is important. However, the ability to emphasize how more research funding has an

impact on the education mission for students also can be of great importance. For our college this includes a focus on developing student research experiences that result from increased research and funding for that research. Building enthusiasm for these fundraising priorities and for the use of internal funds for seed grants requires a clear message in how these opportunities support the range of the goals of the college.

While there are many standard ways that seed programs have operated in a very successful manner, there are somewhat nontraditional approaches that also could be considered. Most approaches tend to provide one infusion of funds. One alternative approach would be to provide very small funds up front with little review of the original idea but with significant review of progress, with strong progress producing additional

funding. A second approach would be to hold a portion of funds to support highly meritorious but unfunded applications that have been submitted for external funding. If an application is viewed positively, it is quite likely that additional progress would have a positive impact. This approach can be ideal to stimulate graduate student funding, where low funding rates for external grants can be a clear impediment to students submitting applications for these grants. Likely neither of these approaches alone would make for an ideal strategy for program evaluation, but there could be value in efforts to consider integrating aspects of these approaches into more traditional seed programs.

Conclusion

Clearly, seed funding is a crucial part of a research-intensive college. At a time where budgets are shrinking, college's may find fewer resources available. For this reason, there must be considerable creativity in how funds are raised and how programs are established to support research productivity along with the strategic goals set. While not without a range of challenges from raising the funds to building the program and selecting awardees, there is no doubt that seed funding can be an essential part of the research mission of a comprehensive liberal arts and sciences college, particularly when developed and conducted in a strategic manner.

Staying Strong and Healthy: Minimizing Cardiovascular and Metabolic Effects of Androgen Deprivation Therapy: A Study in Transition

Sally L. Maliski, Elisabeth Hicks, Alana Enslein
The University of Kansas Medical Center

Over the past decade, use of androgen deprivation therapy (ADT) to treat prostate cancer has risen seven-fold, from 9.8% of patients in 1989-1992 to 74.6% in 1991-2001 (1). ADT is used as neoadjuvant and adjuvant treatment with radiation therapy (RT), to treat recurrence following primary treatment with surgery or RT, or when the cancer is in an advanced stage at diagnosis. While ADT has demonstrated survival benefits, it also is associated with increases in metabolic and cardiovascular risks. Men receiving ADT have been shown to develop dyslipidemia, decreased arterial compliance, increased insulin resistance, weight gain with increased visceral fat deposition, decreased bone mineral density, decreased libido and erectile dysfunction, fatigue, cognitive changes and depression (1-12)

Importantly, cardiovascular disease (CVD) is the leading non prostate-related cause of death among men with prostate cancer, accounting for 11-21% of deaths (13). Men on ADT have a 20% higher risk of myocardial infarction (MI) and congestive heart failure (CHF) than their counterparts not on ADT (14). Also, data from the Prostate Cancer Outcomes Study (PCOS) (15) indicates that prolonged use of ADT increases the risk for diabetes and depression as well as risk of CVD and related MI and CHF (Penson, personal communication). Further, Latino men are more likely to be diagnosed with later stage disease (16-25) and have been underrepresented in previous studies. Latino men in general have higher rates of metabolic syndrome, diabetes, obesity, and hypertension (28, 34-41).

Additionally, we have found that Latino men start treatment for prostate cancer with lower health related quality of life (HRQOL) and that HRQOL declines

over time for men on ADT relative to other treatments for prostate cancer (43). However, we have also found that these men are very interested in making changes that will improve their health, as are the wives of the married men (44). Finally, we are finding that Latino men are unable to identify effects of ADT other than hot flashes and sexual dysfunction demonstrating a lack of awareness of the metabolic and cardiovascular effects of ADT. Starting ADT may be a “teachable moment” to intervene with education and support for progressive individualized behavioral changes to minimize cardiovascular and metabolic effects of ADT. Strategies which have been proven to improve risk profiles in other contexts are being used with this population.

Presented here is a description of an NIH-funded randomized controlled trial of intervention to minimize cardiovascular and metabolic risk for Latino men on ADT. Participants will be randomized

into either an intervention group or an attention control group. Specifically, this study aims to:

- Compare pre- and post-intervention body mass index (BMI), lipid profile, waist/hip circumference and blood glucose levels within and between groups
- Compare pre- and post-intervention HRQOL and depression within and between groups
- Develop and compare explanatory models of nutrition and activity choices between groups
- Evaluate acceptability and benefit of the intervention from participants' perspective

Methods

We are using a RCT design with the added feature of a constructivist grounded theory (20) component with a subset of 30 participants from the intervention group and 30 from the attention control group.

Recruitment

We are recruiting 150 Latino men who have initiated ADT within the past 3 months. The study coordinator is working with office staff of urology clinics in a Midwestern city to identify participants who are potentially eligible for the study and obtain permission for study staff to contact the potential participant to explain the study. Inclusion criteria are:

- Self-identifies as Latino
- Within 3 months of starting ADT
- Diagnosed with prostate cancer
- Able to read and write in English or Spanish
- Not prohibited from exercise by a physician

Men identified by clinic staff and who give permission to be contacted, will receive a call from the bilingual (English-Spanish) study coordinator to explain the study, determine eligibility, answer questions and obtain verbal consent. Men will be randomized into the intervention or control group as they enroll. The study coordinator will contact consenting men to schedule the baseline visit at the translational research unit. Men are encouraged to bring their partner or an adult child. Assistance with transportation is provided if needed.

Procedures

Prior to the baseline visit, the study coordinator will contact all men and instruct them not to eat or drink after midnight before their visit. The coordinator reviews the study, provides direction to the translational research unit and ascertains whether transportation assistance is needed. Men are greeted by the study coordinator upon arrival, introduced to the study nurse, and taken to the unit for their blood draw. Breakfast and beverage are then provided. Next, the study nurse takes the participant's blood pressure, and measures weight, height, waist and hip circumference. The study coordinator and study nurse then administer study instruments including general and disease-specific quality of life measures, a physical activity questionnaire, 24-hour food recall, and depression measure. This concludes baseline measures. The same measures are repeated at six months and 12 months.

Intervention

At the baseline visit, those assigned to the intervention group receive a smartphone. The study cultural liaison instructs men in the use of the phone. All

materials for the intervention education curriculum have been preloaded onto the phone. Men in the intervention group then receive a physical fitness assessment including upper and lower body strength and VO2 Max administered by co-I exercise physiologist. The assessment is then used to develop an individualized progress exercise plan and goals. Similarly, a personalized nutrition plan and goals are developed from the nutrition assessment.

Men and their significant other then receive a weekly call for three months from the study nurse and cultural liaison who is bilingual/bicultural utilizing the smartphone. Each week there is an educational component, activity component, nutrition component, and discussion of goal setting relative to activity and nutrition for the following week. The education topic for each week has been preloaded onto the smartphone along with exercise demonstration videos. Supplemental material can be sent to men as needed. Co-Is consult with the study nurse on nutrition and activity for participants as well any medical questions that arise. Additionally, participants are referred to their primary physician when concerns arise. During the next three months, men receive a monthly call from the cultural liaison to monitor, assist, and coach with the nutrition and activity plan established at the end of the three months of weekly calls. Men then return for the 6-month data collection visit. There is no contact between the six-month and 12-month data collection visits to ascertain stability of intervention outcomes.

Qualitative Component

A constructivist grounded theory approach is being utilized for this portion of

the study to explore differences in decision-making processes related to nutrition and activity between the two groups. A subsample of 30 men from each group will be purposively selected for semi-structured interviews focusing on how they made choices about food selections and exercise. Additionally, men in the intervention group will be asked about their experience of the intervention including what was and was not helpful, ease of use of the smartphone, and ability to set, accomplish, and maintain weekly goals.

Analysis

Analysis will include both quantitative and qualitative techniques. Preliminary analysis will include descriptive statistics for each measure at each time point, assessment of distributional characteristics including outliers, evaluation of missing data, and assessment of reliability. Intervention and control groups will be compared for baseline equivalence on metabolic indicators and HRQOL, as well as other selected factors (e.g. sociodemographics, co-morbidities, medications, primary prostate cancer treatment, acculturation, diet and activity indicators, etc.) using t-tests or chi square tests relevant to the distributional characteristics. The correlation of these possible covariates to the outcome measures will also be examined.

Analyses for the first aim will compare groups in terms of their change in metabolic indicators over time using a mixed effects model for repeated measures, in which group is considered a fixed between-group factor (101, 108). This approach will allow inclusion of covariates determined in preliminary anal-

yses in order to adjust for baseline individual differences that might impact patterns over time. This will also allow for inclusion of all available data points for each individual, even if the data vector is incomplete due to attrition. Each outcome indicator will be considered a dependent variable in separate models. In these models, the group-by-time interaction term will be examined to determine differences between groups over time. Additional contrasts will examine the shape of the pattern of change over time within each group, specific changes from baseline to 6 months and baseline to 12 months within each group, and the difference between groups at each observation point. Interaction effects will allow further examination of covariate relationships to these differences over time. A similar approach will be used to address the second aim with HRQOL and disease-specific HRQOL as dependent variables.

The third and fourth aims will be met through qualitative analysis of interviews conducted at the 12-month data collection visit using grounded theory techniques (Charmaz 2006). All interviews will be audio-recorded and transcribed verbatim. Transcripts will be entered into Atlas ti.v2 for data management. Initially, the PI will read transcripts in their entirety and proceed to segment-by-segment coding. Related codes will be clustered and developed into categories describing process used by participants to make food and activity choices. The study team will independently code several of the same transcripts and meet to confer and agree on categories. The team will then continue coding and categorizing with periodic

meetings to develop full description for each category that includes properties and dimensions and identify relationships among categories. For the intervention group, we will explore categories for explanations of adherence and non-adherence. We will also compare the explanatory frameworks developed for each group relative to nutrition and activity decision making. These explanatory frameworks will be used to contextualize the interpretation of the outcome measures taking into account participants' decision process, context factors which influenced outcomes, perception of importance and relationship of nutrition and activity to HRQOL and health during ADT.

Institutional Transitioning of the Study

At this point, the study is in transition between two major universities. The process is a lengthy and complex one which demands constant communication. An initial step involved identifying the resources and technology at the new institution necessary to conduct the study. This included building the infrastructure with new co-investigators, consultants, as well as hiring a new research manager and research staff. Fortunately, the resources and expertise were available at the new institution and there has been immense support from interdisciplinary teams.

As recruitment is pertinent to study success, it was necessary to be proactive about understanding where the potential participant pool of Latino men starting ADT would be coming from. We found that this pool was much smaller at the new university; however, an African

American population was more abundant. We thought it would be interesting to explore this underrepresented population as well, and thus, were granted permission by the NIH to expand our recruitment to men of any ethnicity. The new team has been able to identify strategies for recruitment which include working with local urology clinics and community groups for the identification and potential enrollment of participants. During this time, study work at the original institution was being transitioned from recruitment to preparing for the transfer of the study.

Mechanisms for transfer of data collection procedures, documentation, tracking, storage and management had to be developed. This continues to involve collaboration and communication between many different parties, including but not limited to the research manager at the new institution with the study staff at the transferring institution, as well as medical informatics at the new institution to build the framework for data collection and storage. Additionally, study equipment such as smartphones, resistance bands, heart rate monitors, and gift cards for participants had to be moved from one institution to the other.

Finally, there has been ongoing communication with the NIH to meet requirements for relinquishment of the grant by the original institution and acceptance by the new institution. There have been both formal and informal communications to accomplish this. This has included reformulation of the study budget, modification of methods to fit the new site, and obtaining IRB approval at the new institution. During this time, recruitment and study activities have had

to be suspended until the grant is officially transferred to the new institution. As there are many moving parts involved in building a new infrastructure and developing resources while maintaining communication with the original site and overseeing transitional processes, we have come across unforeseen limitations. Fortunately, these hurdles have provided opportunities to learn, grow, and develop new processes to benefit the future of the study. While it has been an arduous process, we have learned that maintaining close and open communication among all parties is critical to a successful grant transition.

Recommendations

Primarily, communication is essential. As soon as it is known that a PI will be requesting to transfer a grant, it is imperative that he/she has a discussion with the current institution's dean or associate dean for research and with the counterpart at the receiving institution. Being proactive about and maintaining quality communication is necessary for both institutions. Concurrently, the PI can be informing the study program officer of the impending transfer and seek guidance as to NIH process requirements. Understanding the NIH guidelines up front will help for a smoother transition. Next, optimal timing for relinquishment and acceptance can be determined such that budgetary modifications can be negotiated and approved with minimal loss of time for study activities. These timelines will dictate when it is appropriate to ship materials to the new site as well as data and systems transfers. The goal of a grant transfer is to have everything in place at the new institution in order to start study activities as soon as the transfer is official.

In addition to starting procedures and data collection at the new site, it is just as important to accommodate completion of study participants at the original site with smooth closeout operating procedures.

References

1. Cooperberg M, Grossfield G, Lubeck D, Carroll P. National practice patterns and time trends in androgen ablation for localized prostate cancer. *Journal of the National Cancer Institute*. 2003; 95: 981-9
2. Higano C. Side effect of androgen deprivation therapy: Monitoring and minimizing toxicity. *Urology*. 2003; 61 (2 suppl 1): 32-8
3. Johansson E, Bill Axelson A, Holmberg L, Onelov E, Johansson JE, Steineck G, et al. Time, symptom burden, androgen deprivation, and self-assessed quality of life after radical prostatectomy or watchful waiting: the Randomized Scandinavian Prostate Cancer Group Study Number 4 (SPCG04) clinical trial. *Eur Urol*. 2009; 55 (2): 422-30. Epub 2008/09/12. Doi: 10.1016/j.eururo.2008.08.054. PubMed PMID: 1873877. NIHMS#: NIHMS88484.
4. Kattan MW. Measuring hot flashes in men treated with hormone ablation therapy: an unmet need. *Urol Nurs*. 2006;26(1):13-8. Epub 2006/03/28. PubMed PMID: 16562382.
5. Labrie F, Cusan L, Gomez J, Belanger A, Candas B. Long-term combined androgen blockade along for localized prostate cancer. *Molecular Urology*. 1999;3:217-26.
6. Levine G, D'Amico A, Berger P, Clark P, Eckel R, Keating N, et al. Androgen-Deprivation Therapy in Prostate Cancer and Cardiovascular Risk. *CA: A Journal for Clinicians*. 2010;60(3):294-01. PubMed Central PMCID: PMC3049943.
7. Kabir S, Mancuso P, Rashid P. Androgen deprivation therapy--managing side effects. *Aust Fam Physician*. 2008;37(8):641-6. Epub 2008/08/16. PubMed PMID: 18704213.
8. Nishiyama T, Ishizaki F, Anraku T, Shimura H, Takahashi K. The influence of androgen deprivation therapy on metabolism in patients with prostate cancer. *Journal of Clinical Endocrinology and Metabolism*. 2005;90:657-66.
9. Saylor PJ, Smith MR. Metabolic complications of androgen deprivation therapy for prostate cancer. *J Urol*. 2013;189(1 Suppl):S34-42; discussion S3-4. Epub 2012/12/19. doi: 10.1016/j.juro.2012.11.017. PubMed PMID: 23234628.
10. Tsai H, D'Amico A, Sadetsky N, Chen M, Carroll P. Androgen deprivation therapy for localized prostate cancer and the risk of cardiovascular mortality. *Journal*

- of the National Cancer Institute. 2007;99(20):1515-24.
11. Basaria S, Muller D, Carducci M, Egan J, Dobs A. Hyperglycemia and insulin resistance in men with prostate carcinoma who receive androgen deprivation therapy. *Cancer*. 2006;106:581-8.
 12. Lubeck D, Grossfeld G, Peter R. The effect of androgen deprivation therapy on health-related quality of life in men with prostate cancer. *Urology*. 2001;58(suppl. 2A):94-100.
 13. Efstathiou JA, Bae K, Shipley WU, Hanks GE, Pilepich MV, Sandler HM, et al. Cardiovascular mortality after androgen deprivation therapy for locally advanced prostate cancer: RTOG 85-31. *J Clin Oncol*. 2009;27(1):92-9. Epub 2008/12/03. doi: 10.1200/jco.2007.12.3752. PubMed PMID: 19047297; PubMed Central PMCID: PMC2645096.
 14. Saigal C, Gore J, Krupski T, Hanley J, Schonlau M, Litwin M. Androgen deprivation therapy increases cardiovascular morbidity in men with prostate cancer. *Cancer*. 2007;110:1493-500.
 15. Penson D. ADT Risk. In: Maliski SL, editor. Thousand Oaks 2010.
 16. Klein JB, Nguyen CT, Saffore L, Modlin C, 3rd, Modlin CS, Jr. Racial disparities in urologic health care. *J Natl Med Assoc*. 2010;102(2):108-17. Epub 2010/03/03. PubMed PMID: 20191923.
 17. ACS. Cancer Facts and Figures. American Cancer Society, 2012.
 18. Bennett C, Ferreira M, Davis T, Kaplan J, Weinberger M, Kuzel T, et al. Relation between literacy, race, and stage of presentation among low-income patients with prostate cancer. *Journal of Clinical Oncology*. 1998;16(9):3101-4.
 19. Bradley C, Given C, Roberts C. Late stage cancers in a Medicaid-insured population. *Medical Care*. 2003;41(6):722-8.
 20. Danley KL, Richardson JL, Bernstein L, Langholz B, Ross RK. Prostate cancer: trends in mortality and stage-specific incidence rates by racial/ethnic group in Los Angeles County, California (United States). *Cancer Causes Control*. 1995;6(6):492-8. PubMed PMID: 8580296.
 21. Dayal HH, Chiu C. Factors associated with racial differences in survival for prostatic carcinoma. *J Chronic Dis*. 1982;35(7):553-60.
 22. Eisen S, Waterman B, Skinner C, Scherrer J, Romeis J, Bucholz K, et al. Sociodemographic and health status characteristics associated with prostate cancer screening in a national cohort of middle-aged male veterans. *Urology*. 1999;53:516-22.
 23. Halpern M, Ward E, Pavluck A, Schrag N, Bian J, Chen A. Association of insurance status and ethnicity with cancer stage at diag-

- nosis for 12 cancer sites: A retrospective analysis. *Lancet*. 2008;9:222-31. PMID: 18282806.
24. Gilligan T. Social disparities and prostate cancer: Mapping the gaps in our knowledge. *Cancer Causes and Control*. 2005;16:45-53.
 25. Penson D, Stoddard M, Pasta D, Lubeck D, Flanders S, Litwin MS. The association between socioeconomic status, health insurance coverage, and quality of life in men with prostate cancer. *J Clin Epidemiol*. 2001;54.
 26. Allicock M, Campbell MK, Valle CG, Barlow JN, Carr C, Meier A, et al. Evaluating the implementation of peer counseling in a church-based dietary intervention for African Americans. *Patient Educ Couns*. 2010;81(1):37-42. Epub 2010/01/02. doi: 10.1016/j.pec.2009.11.018. PubMed PMID: 20044231.
 27. Enger S, Van Den Eeden S, Sternfeld B, Loo K, Quesenberry Jr C, Rowell S, et al. California men's health study (CMHS): A multi-ethnic cohort in a managed care setting. *BMC Public Health*. 2006;6(172-181).
 28. Haskell W, Lee I, Pate R, Powell K, Blair S, Franklin B, et al. Physical activity and public health: Updated recommendations for adults from the American College of Sports Medicine and American Heart Association. *Circulation*. 2007;116:1081-93.
 29. Ervin RB. Prevalence of metabolic syndrome among adults 20 years of age and over, by sex, age, race and ethnicity, and body mass index: United States, 2003-2006. *Natl Health Stat Report*. 2009(13):1-7. Epub 2009/07/29. PubMed PMID: 19634296.
 30. Martinez SM, Ainsworth BE, Elder JP. A review of physical activity measures used among US Latinos: guidelines for developing culturally appropriate measures. *Ann Behav Med*. 2008;36(2):195-207. Epub 2008/10/16. doi: 10.1007/s12160-008-9063-6. PubMed PMID: 18855091.
 31. Ramirez A, Chalela P, Gallion K, Velez L. Energy balance feasibility study for Latinas in Texas: A qualitative assessment. *Prev Chronic Dis*. 2007;4:A98.
 32. Sobalske M. Health care seeking among Mexican American men. *J Trans Cult Nurs*. 2006;17(2):129-38.
 33. Thompson E, Berry D, Nasir L. Weight management in African-Americans using church-based community interventions to prevent type 2 diabetes and cardiovascular disease. *J Natl Black Nurses Assoc*. 2009;20(1):59-65. Epub 2009/08/21. PubMed PMID: 19691185.
 34. Two Feathers J, Kieffer E, Palmisano G, Anderson M, Sinco B, Janz N, et al. Racial and ethnic approaches to community health (REACH) Detroit partnership:

- Improving diabetes-related outcomes among African American and Latino adults. *Am J Public Health*. 2005;95(9):1552-60.
35. Andersen R, Lewis S, Giachello A, Aday L, Chiu G. Access to medical care among Hispanic population of the southwestern United States. *J Health Soc Behav*. 1981;22(1):78-89.
 36. Association AH. *Heart Facts 2007: Latino/Hispanic Americans*. American Health Association, 2007.
 37. Colleran K, Richards A, Shafer K. Disparities in cardiovascular disease risk and treatment: Demographic comparison. *J Investig Med*. 2007;55(8):415-22.
 38. Meadows TA, Bhatt DL, Hirsch AT, Creager MA, Califf RM, Ohman EM, et al. Ethnic differences in the prevalence and treatment of cardiovascular risk factors in US outpatients with peripheral arterial disease: insights from the reduction of atherosclerosis for continued health (REACH) registry. *Am Heart J*. 2009;158(6):1038-45. Epub 2009/12/05. doi: 10.1016/j.ahj.2009.09.014. PubMed PMID: 19958873.
 39. Valdez R, Giachello A, Rodriguez-Trias H, Gomez P, de la Rocha C. Improving access to health care in Latino communities. *Public Health Report*. 1993;108(5):534-9.
 40. Vega WA, Rodriguez MA, Gruskin E. Health disparities in the Latino population. *Epidemiol Rev*. 2009;31:99-112. Epub 2009/08/29. doi: 10.1093/epi-rev/mxp008. PubMed PMID: 19713270.
 41. Zeno SA, Kim-Dorner SJ, Deuster PA, Davis JL, Remaley AT, Poth M. Cardiovascular fitness and risk factors of healthy African Americans and Caucasians. *J Natl Med Assoc*. 2010;102(1):28-35. Epub 2010/02/18. PubMed PMID: 20158133.
 42. Krupski T, Fink A, Kwan L, Maliski S, Connor S, Clerkin B, et al. Health-related quality of life in low-income, uninsured men with prostate cancer. *Journal of Health Care for the Poor and Underserved*. 2005;16(2):375-90.
 43. Zavala MW, Maliski SL, Kwan L, Miller DC, Fink A, Litwin MS. Longitudinal quality of life in low-income men in a state-funded prostate cancer treatment program. *J Health Care Poor Underserved*. 2008;19(1):200-14. Epub 2008/02/12. doi: 10.1353/hpu.2008.0026. PubMed PMID: 18263996.
 44. Maliski SL, Rivera S, Connor S, Lopez G, Litwin MS. Renegotiating masculine identity after prostate cancer treatment. *Qual Health Res*. 2008;18(12):1609-20. Epub 2008/10/29. doi: 10.1177/1049732308326813. PubMed PMID: 18955461.

Attracting and Retaining Competitive Faculty – Startups, Core Facilities, and Investment Strategies...Oh My!

Peter K. Dorhout, Vice President for Research
Kansas State University

This paper explores the challenges of attracting and retaining competitive faculty at Kansas State University. In order to reach its strategic goal to be a top 50 public research university by 2025, the university has focused on student achievement, retention, and success, along with responding to state initiatives to provide more engineering graduates to meet future state needs. Kansas State is committed to supporting its faculty and graduate programs by developing strategies to improve salaries and other forms of support. A key factor in meeting the goal of a top 50 university, is the ability to grow the research enterprise through focused investments in core facilities and institutional support structures that will enable faculty to be competitive for extramural funding, particularly in interdisciplinary and inter-institutional grant programs. Moreover, improving the policies and processes that enable partnerships with industry to flourish and faculty to pursue patents and technology licenses will open new doors for the institution. In an environment of diminishing state appropriations for higher education, it has become more critical to develop diversified strategies to fund startup commitments for faculty and core facilities that will support new hires or retain key members of our community.

The presentation that follows builds off of the anxiety that I experienced starting my position as the Vice President for Research in 2016. Startups, core facilities, and investments...oh my. This anxious chant, which has hounded my first six months on the job, reminded me of a famous journey for a young girl in Kansas, set in earlier days, and the challenges facing Metro-Goldwyn-Mayer studios in the 1930s to adapt a children's story to new film-making technologies and a broader audience of movie fanatics. Does the metaphor of creating a movie during the Depression, investing in new technologies and methods, and taking chances on new actors and actresses compare with

my challenges and opportunities? Does the storyline of Dorothy's journey align with the broader university research enterprise? Startups, core facilities, and investments...oh my...three very scary creatures in the university jungle.

The Opening – Scene 1. The Talk.

The invitation to speak at the Merrill Research Retreat in July 2016, came with the caveat that I could speak about anything I desired, but the organizers needed the title as soon as possible. What had been plaguing my thoughts as a new vice president for research at Kansas State University were the requests that seemed to be rolling in near the end of the fiscal year for budget reduction plans. Kansas

was enjoying another in a long litany of missed monthly revenue targets for the state, which was putting pressure on the annual appropriation for higher education.

Kansas State University was also completing the first five years of an ambitious fifteen-year strategic plan to become a top 50 public research university by 2025, during which time state revenues were not supporting the necessary investments for sustainable growth in the research enterprise. We were entering the perfect storm of flattening student enrollments (high school enrollments were declining), increasing retirements (aging baby boomers), and a reduced state appropriation (state revenues). Finding resources to address faculty retention and hiring quickly rose to the top of my concerns list.

Startups, core facilities, and investment strategies for research are the keys to attracting and retaining competitive faculty. Startups, core facilities, and investments...oh my.

The 2014 Higher Education Research and Development survey¹ may be interpreted to reveal the rank ordering of public universities in the U. S., where it placed Kansas State in the 73rd spot on the list. The Arizona State University Center for Measuring University Performance placed K-State at number 70 in its 2014 annual report on Top American Research Universities.² To be included in the top 50 public university ranks, Kansas State will need to increase its annual research expenditures by nearly a factor of 1.75 by 2025.

Such a goal is neither inconceivable nor impossible. Compounded growth at

6.5% per year will exceed our goal. From 1990 to 2000, the research expenditures at Kansas State grew by 9.5% per year.³ During that same period, the increase in federal research spending was nearly flat, growing only by 3% over the entire ten-year period.⁴ From 2000 to 2010, the research expenditures at Kansas State grew by 7.5% per year; the federal budget for research grew by 4% per year. Even as the federal research expenditures contracted from 2010 to 2015 by 4% per year, the research expenditures at Kansas State grew by 3.8% per year.

Since 1990, the university has consistently out-performed the federal research budget growth or contraction, but have we reached that fork in the road where the wrong choice may take us off the smooth path? Will our confluence of budgetary low-pressure systems bring about a perfect wall cloud to whip up a fury of tornadic winds that will bring down our house? Startups, core facilities, and investments...oh my. This sounds familiar....

Flashback – Scene 2.

I imagine the Metro-Goldwyn-Mayer writers in mid 1936, 80 years prior to this research retreat of the Merrill Research Center, struggled with their perfect storm following some lean years. MGM, only recently converted to “talkies” and starting to compete well for talent and a share of the movie industry, was seeking a block buster movie following the death of Irving Thalberg.⁵ United Artists group, including Walt Disney and Hal Roach, was competing successfully for market share, and the new technologies of the time – sound, color movies, and other cin-

ematic shifts – were impacting the business.⁶ Nevertheless, the Depression had taken its toll on the movie industry, which, by 1936, was beginning to enjoy a renaissance due to new technologies and equipment.⁷

In 1938, writers began working with the script for a fantasy story that had flopped as a movie in the mid 1920s, but had renewed interest given the color technology of the time.⁸ Disney had penned a contract for exclusive rights for the Technicolor three-strip process for cartoons in 1934, with an embargo until 1936, and he was in the production phase of *Snow White*, which was released in 1937. MGM was looking for a hit, but it would come at a cost. The startup was incredible – the mechanics of Technicolor filming and showing in the mid-1930s was cumbersome and incredibly costly, recruiting and retaining new actors and actresses to play the parts were challenging, and the investments would not pay off for almost 10 years.

So, when production began in 1938 on *The Wizard of Oz*, the storm had not yet cleared. MGM was also betting on another major book to become a blockbuster motion picture: *Gone with the Wind* started production the same year, and it would steal away one of the Oz directors. Buddy Ebsen, first cast as the Tin Man, suffered a reaction to the aluminum paint used on him and had to leave the filming.⁹ The cast of munchkins and Emerald citizens commanded a colossal costume budget. The film's special effects left a number of critics wanting for something better, and while nominated for an Academy Award, the Best Picture Award went to *Gone with the Wind*. Best Song and Best

Original Score awards were the only two accolades received for the film in 1940. It would be nearly 70 years later that the American Film Institute listed *The Wizard of Oz* among the Top 100 movies, songs, and quotes, including one that is dear to us in Kansas, "Toto, I've got a feeling we're not in Kansas anymore."

Present Day – Scene 3. The Leader.

Compare and contrast the university version of the challenges of attracting, retaining, and investing in the faculty and the research enterprise with those experienced by Director Victor Fleming, who also left Oz to finish *Gone with the Wind*. So, let's focus first on the change in leadership. The screenplay for Oz did undergo regular tweaking as scenes were rehearsed, filmed, and reviewed. Like a university Strategic Plan, the screenplay lays out a basic vision and framework for the movie, but reality sometimes gets in the way. As the directors changed, some of the character traits changed, altering slightly or significantly from the way L. Frank Baum envisioned them. Indeed, this is a delicate balance between how so many readers of the Oz series of books viewed the characters and their personalities and how they should appear on film – the difference between fame and flop often lies in the balance.

University leaders are faced with the inherited legacies of those who led before them: Strategic Plans, alumni culture, and campus culture – "we've always done it this way." When leadership changes, there is a moment of chaos when people question the script, the blocking, and the character relationships. Will the Strategic Plan still be valid with the new leader? Will we continue to follow our

previous processes for making decisions? Will the institutional supporters continue to help meet the financial goals of the Plan?

Unlike the screenplay, the university community should be involved in creating the Strategic Plan. The leader provided some of the vision, but the “cast” is engaged in creating the living document that moves the story forward. While the paths to get to the desired outcome may be different under new leadership, or as a result of changing funding climates, the goal or goals should remain the same.

An effective Plan should be developed from the ground up, not the top down, so the “screenplay” should be owned by the entire cast, which is what makes it the strongest document it can be.¹⁰ Yet, the university should not be considered only as an “organization as theater,” which serves as the metaphor for this paper. Bolman and Deal wrote, “the symbolic frame encourages us to view organizations as theater and organizational activities as dramaturgical performances played to both internal and external audiences,” when considering strategic planning.¹¹ Citing Cohen and March, “there are four symbolic roles for plans in universities: 1. Plans are symbols; 2. plans become games; 3. plans become excuses for interactions; and 4. plans become advertisements.”¹²

Flashback – Scene 4. The Plan.

There are four symbolic roles for the Plan. First, there is the symbol itself. The Plan could symbolize that “all’s well, and even better just around the corner.” For Dorothy and her traveling companions in the story, the symbol is the Emerald City – that’s where the Wizard resides, and, to

paraphrase Kander & Ebb,¹³ if they could make it there, they could make it anywhere. I appreciate that I should not mix the story line of *Oz* with the making of the movie, but the two are intertwined. The dynamic environment of the movie production was influenced by the characters and morals of the story as well as by the dynamics of the leadership and the technology changes impacting filming. The screenplay, and arguably the story within it, were part of the symbolic Plan.

When Plans become games, they embark on a new line of strategy – a test of wills. Within the story of *Oz*, Dorothy and the Witch were engaged in a test of wills, as were her three traveling companions who were trying to storm the castle to save her. Within the filming and production of the movie, there was a test of wills between actors, directors, and producers, each with his or her own vision of how the story should be portrayed.

Screenplays do become susceptible to changing conditions. So, too, with Strategic Plans. For example, not reaching a particular goal or metric is often a time to retrench and refresh the Plan. Not having the technology yet to float a Good Witch in a bubble or melt a Not-So-Nice Witch, meant changing the scenes rather than bringing the cast together to discuss how to move forward with the available technologies. When we in the university setting have a Plan, it is often the excuse for not discussing tactics any longer, which often creates animosity towards the Plan and not the leaders who are using it in this manner.

Finally, ever mindful of the patrons of the project, the screenplay can often be

used as an advertisement for the beauty of the finished product. *Oz* showcased fantasy in a manner not yet seen by audiences of the times. The Emerald City idolized the good life of the average Emerald citizen, complete with the full make-over of the day. The movie itself became an advertisement for new color cinematography and a rising singing star under contract with MGM.

The Strategic Plan for transforming any organization, like the screenplay for *Oz*, is only as good as the talent it guides and the leadership that embraces creativity and finds a path forward. A screenplay does not mention all of the blocking and tackling required on each scene, let alone outline precisely what success will resemble when completed, and a Plan

does not necessarily provide all of the tactics required to be successful. Implementation will be fraught with obstacles easily be enhanced by the talent that it gathers along the way.

Present Day – Scene 5. Change for the Better.

Investment strategies are unique to each institution and situation, but they reach back to the screenplay, and the ultimate goal. For Kansas State, that goal is to become a Top 50 Public Research Institution by 2025. No strategies or tactics there. No metrics other than how the nation defines top 50 universities. In the opening scene, I set the stage for how that goal would be measured and cited research and development spending. The government spending trend on R&D actually pales in comparison to the overall

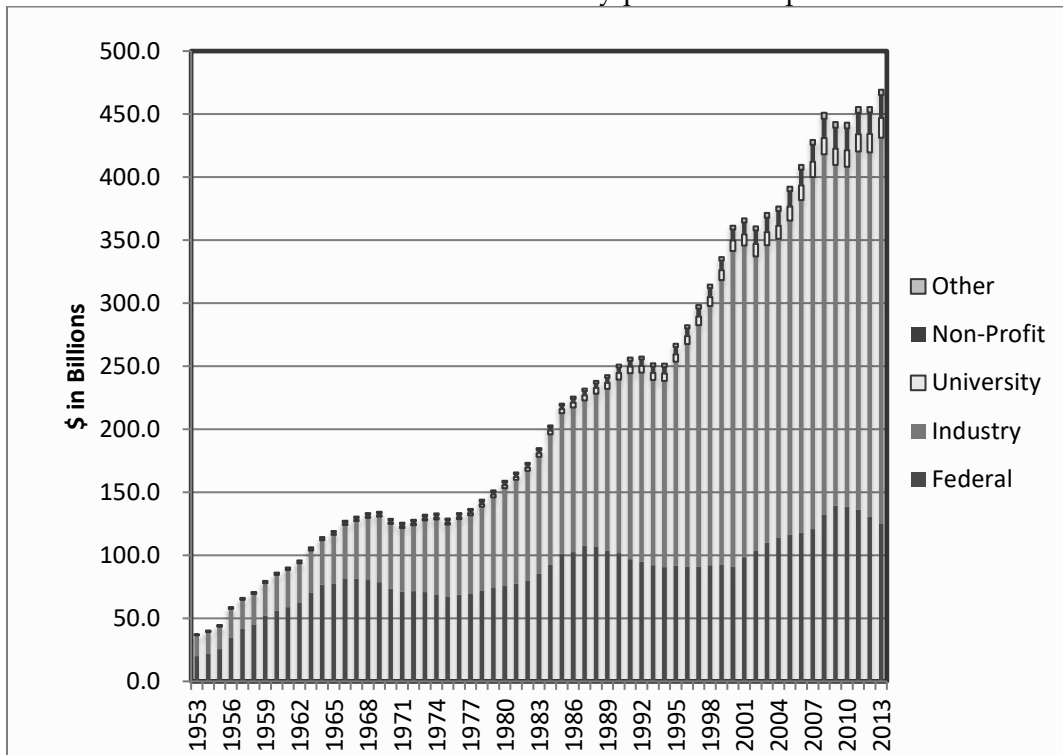


Figure 1. Total Research & Development Spending by Sector Over 60 Years

spending by industry and others.⁴ Consider the graph in Figure 1 constructed from data from AAAS. In 1990, the federal government provided 40% of the total investment in R&D funding in the U. S. By 2010, that fraction fell to 30% of a total expenditure profile that increased by 77%, from roughly \$250 billion per year to over \$443 billion per year. Industry investments in research during this 20-year period grew by nearly 100% compared to the growth in federal investments of only 36%. Moreover, 2010 represented a high-water mark for federal R&D spending.

Not all R&D funding is created equal. The share of federal R&D funding going to academic basic research has been steadily growing from the 1950s until today,¹⁴ with roughly 24% of the total R&D funding directed to basic research, of which over half goes to universities. Another 24% of the federal R&D budget is directed to applied research, of which about 25% goes to university research efforts. The largest share of federal funding, over 50%, goes to support development, and universities are very small players in this area. In fact, in the larger picture of a \$450 billion per year total R&D budget in the U.S., only about 15% funded university research, basic, applied, and development, in 2013. The portfolio of research at Kansas State University in 2014 was not much more diversified than many other public research universities.¹ Only 3% of the total research expenditures for K-State came from industry partners in research. About the same percentages each came from each private foundations and gifts.

Support for our research enterprise originated from federal grants (roughly 33%), institutional funds (33%), and the balance from state and local funding (25%). Based on the sector where the funding is or is not poised for growth, the research enterprise at K-State could be greatly enhanced by creating a culture that embraces industry partnerships; moreover, such a culture aligns with our land-grant mission, which is dedicated to bringing our new knowledge out to the public for public consumption.

Investing in research to grow the enterprise includes supporting infrastructure, facilities, and new faculty hiring strategies. Facilities and Administrative costs charged to grants should be dedicated to investments in the research infrastructure. However, changing state budgets have meant that some of those resources have been redirected to cover budget shortfalls in research support areas. Building and deferred maintenance budgets have also been impacted that also stress the F&A resources. Startup costs for new faculty hiring have been growing each year. The annual report from Burroughs-Wellcome in 2010 put average startup costs over \$800,000 for biomedical sciences faculty, over \$710,000 for physical sciences, and \$720,000 for engineering faculty, and it hasn't gotten cheaper.¹⁵

With diminishing state resources putting pressure on F&A budgets, investing in core facilities or other areas of the research enterprise has become challenging. Faculty salary stagnation due to state budgetary pressures has put many of our best performers at risk for being recruited away. Recruiting and retaining

faculty has become a perennial challenge for state universities, particularly given the resource constraints. Nevertheless, we must be strategic in our hiring as outstanding faculty retire and as programs grow to meet student demands.

Universities must identify their strengths and invest in core facilities that permit groups of faculty and staff to work collaboratively around larger projects. While shared equipment may not be ideal in some cases, larger equipment that requires a support infrastructure to maintain it or staffing to train students to use it will be less cost-prohibitive. While operating as pure cost centers is not often sustainable, some central support for shared facilities can reduce the costs to research grants and contracts. For some institutions, this model is a culture shift from how things have been.

While these changes may not seem like they are for the better, changes such as these can be for good. The sustainability of public and land-grant research universities depends on culture change. Partnering with industry, large or small, ensures that our research is supported through diversified funding sources and that our best ideas are making it to the market place. Evaluating investment strategies for our limited Facilities & Administrative resources should ensure sustainability of our strengths and enable us to continue to educate the students who become our next generation of Kansas professionals.

Present Day – Scene 6. There’s No Place Like Home.

After more than a decade in theaters, during a very difficult time in our nation’s history, *Oz* finally turned a profit

and became one of our most beloved films. Good had triumphed over evil on so many fronts. In the 1940s, millions of young Americans made journeys that they never should have made, and many made the ultimate sacrifice so that good would prevail. Dorothy’s journey would serve as a metaphor for so many different coming-of-age events; the story is timeless and easily understood by generations since and to come.

Does the journey of the making of *Oz* serve as a good metaphor for the coming-of-age for the research enterprise? I submit that it does. I have accounted for prohibitive costume and special effects costs, technology costs in filming, and the competition with other films luring away some of the best actors and directors of the times. I accounted for changing plans that impacted what the viewers saw on film and how the characters were portrayed. Plans and screenplays that, when proven to be inflexible and unresponsive to changing conditions, find their way into the dustbin of history. So, too, will be the fate of our plans for transforming the research enterprise if we ignore the opportunities to adjust our strategies as the conditions warrant.

“But wait,” you say? “Haven’t you forgotten the ending of the story?”

On the remote chance that you, the reader, grew up in an environment devoid of this particular movie or book, I will not provide a spoiler. I will tell you that Dorothy matured during her time in *Oz* and mustered the wisdom, the courage, and the heart to succeed on her personal journey. She was confronted by the allure of the newness and the color of a magical place, yet she prevailed. To use

the university as a metaphor for her experience, she had an unusual internship opportunity, she networked with the denizens of Oz, and she was able to work with a diverse team of interdisciplinary colleagues. Sometimes the critical infrastructure to support her journey was paved with gold, and other times it was a foreboding and entangling forest of self-doubt and fear. The Wizard who was “all powerful” and came across gruff, turned out to be a horse of a different color. In short, Dorothy grew up.

Why do we gather each year with colleagues, mustered together by the leadership of the Merrill Advanced Studies Center at the University of Kansas, to fo-

cus on improving the research environment for our institutions? I do not believe that the conference is organized to share only what we have done, or done well, but what we are going to do, the journey we will take, and the revelations we will bring back. Why we gather together across the four-state region to confront our challenges and combat our demons is not to boast about our talents, but to address our issues through collective dialog and interaction. Our journey at Kanas State is one that is focused on improving our part of the world, changing for the better so our students and faculty will prevail, because there really is no place like home.

References

¹ <https://www.nsf.gov/statistics/srvyherd/>

² <https://mup.asu.edu/Top-Universities>

³ <http://www.k-state.edu/research/our-research/facts-figures.html>

⁴ <https://www.aaas.org/page/historical-trends-federal-rd>

⁵ *International Directory of Company Histories*, Vol. 25. St. James Press, 1999.

⁶ T. Elway, *Popular Science*, 1923, 59.

⁷ H. Kalmus, *J. Soc. Motion Picture Eng.*, 1938, 52.

⁸ J. Frick et al., *The Wizard of Oz: The Official 50th Anniversary Pictorial History*. 1986, New York, NY: Warner Books, Inc.

⁹ A. Smalling, *The Making of the Wizard of Oz: Movie Magic and Studio Power in the Prime of MGM*. 1989, New York, NY, Hyperion.

¹⁰ J. H. Zenger, J. Folkman, *The Extraordinary Leader*, 2002, New York, NY, McGraw-Hill.

¹¹ L. G. Bolman & T. E. Deal, *Reframing Organizations, 3rd Ed.*, 2003, New York, NY, Wiley & Sons.

¹² M. Cohen & J. G. March, *Leadership and Ambiguity*, 1974, New York, NY, McGraw-Hill.¹ J. Kander & F. Ebb, *New York, New York*, 1977, Copyright, United Artists Co..

¹³ <https://ncesdata.nsf.gov/fed-funds/2014/>

¹⁴ Burroughs-Wellcome 2010 Fund Report, www.bwfund.org last accessed July, 2016.

¹⁵ Burroughs-Wellcome 2010 Fund Report, www.bwfund.org last accessed July, 2016.

RETREAT PARTICIPANTS 2016

Keynote Speaker

University of California, Riverside

Kim Wilcox, Chancellor

Iowa State University

Jerry Zamzow, Assistant Vice President for Research

Kansas State University

Peter Dorhout, Vice President for Research

April Mason, Provost & Senior Vice President

The University of Iowa

Sarah Larsen, Associate Dean, Graduate College and Professor, Department of Chemistry

The University of Kansas

Abiodun Akinwuntan, Dean and Professor, KUMC School of Health Professions

Richard Barohn, Vice Chancellor for Research, KUMC

Neeli Bendapudi, Provost and Executive Vice Chancellor

John Colombo, Director, Life Span Institute

Joseph Heppert, Associate Vice Chancellor for Research

Mary Lee Hummert, Interim Vice Chancellor for Research

Yo Jackson, Professor and Senior Scientist, Clinical Child Psychology Program/Life Span Institute

Carl Lejuez, Dean, College of Arts & Sciences

Sally Maliski, Dean and Professor, KUMC School of Nursing

Mabel Rice, Fred and Virginia Merrill Distinguished Professor of Advanced Studies; Director, Merrill Advanced Studies Center

Deb Teeter, University Director, Office of Institutional Research and Planning

Sara Thomas Rosen, Senior Vice Provost (Current Dean, College of Liberal Arts & Sciences, Georgia State University)

University of Missouri

Brian L. Foster, Provost Emeritus, Emeritus Professor of Anthropology

Alex Barker, Director, Museum of Art and Archaeology

University of Nebraska-Lincoln

William Charlton, Associate Vice Chancellor for Research

Prem S. Paul, Vice Chancellor for Research and Economic Development

Notes

The University of Kansas prohibits discrimination on the basis of race, color, ethnicity, religion, sex, national origin, age, ancestry, disability, status as a veteran, sexual orientation, marital status, parental status, gender identity, gender expression and genetic information in the University's programs and activities. The following person has been designated to handle inquiries regarding the non-discrimination policies: Director of the Office of Institutional Opportunity and Access, IOA@ku.edu, 1246 W. Campus Road, Room 153A, Lawrence, KS, 66045, (785)864-6414, 711 TTY.