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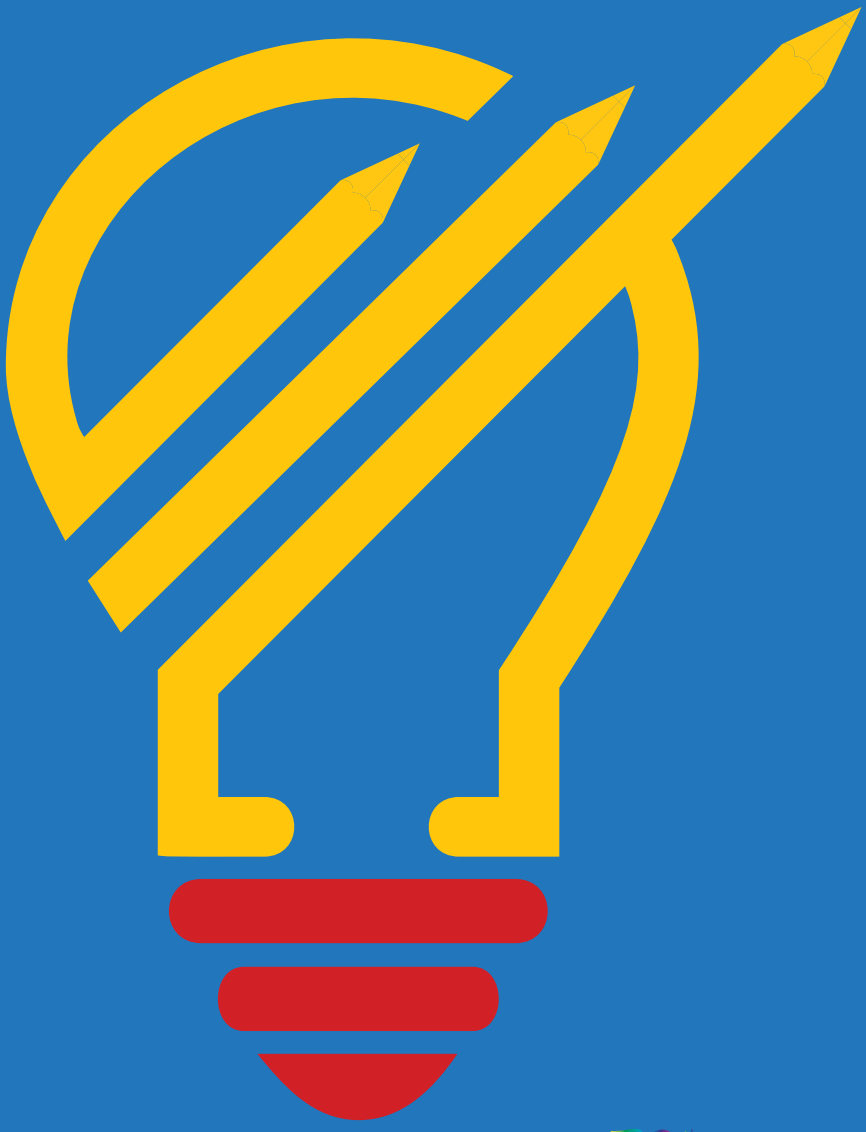

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FROM THE EDITOR'S DESK

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From the Editor's Desk

Timothy L. Linker
High Point University

The *Journal of Research Administration (Journal)* is the premier scholarly resource addressing excellence in research management, administration and development of the profession. The Journal serves as a pathfinder for how to effectively grow and manage your research enterprise. As our profession evolved and spread throughout the globe over recent decades, it took on a span of tasks that requires distinctive skill sets. This issue of the Journal reflects the breadth of duties that have now become the norm. Wells and co-authors, in their paper entitled "*Allocation of R&D Equipment Expenditure Based on Organization Discipline Profiles*," offer a new approach for determining the distribution of research and development equipment funding across large organizations. The authors compare equipment benchmarking data from the National Science Foundation (NSF) to comparable indicators from the Commonwealth Scientific and Industrial Research Organization, which is the Australian equivalent to the NSF. Dr. Dwayne Lehman, in his article "*Organizational Cultural Theory and Research Administration Knowledge Management*" applies cultural theory as a lens to interrogate the research administration community of practice. Lehman identifies four factors essential to promoting a learning culture in our community of practice and higher education. Liberale and Kovach offer a case study in applying Lean Six Sigma methodology to the work of an Institutional Review Board (IRB) in an effort to reduce the time of review and decision-making in their article "*Reducing the Time for IRB Reviews: A Case Study.*"

In the article by Wiebe and Maticka-Tyndale, entitled "*More and Better Grant Proposals? The Evaluation of a Grant-Writing Group at a Mid-Sized Canadian University*," they offer a case study on the effectiveness of implementing Dr. Robert Porter's approach to stimulating proposal development. Using Dr. Porter's approach, the authors saw significant increases in both proposal submission and funding rates. Hottenstein, in her article "*Protecting the Teaching and Learning Environment: A Hybrid Model for Human Subject Research Public Policy Implementation*," examines the intersection of robust human subject compliance and enabling undergraduate research through Ripley's Model of the Policy Process. Hottenstein's findings indicate that a hybrid model offers a reliable compliance mechanism to encourage undergraduate research. In the article "Using Competencies to Transform Clinical Research Job Classifications," Brouwer and co-authors outline a process and tools developed at Duke University for classifying and remapping clinical trials staff.

As always, I want to thank the Journal's Deputy Director, Dr. Nathan Vanderford, and the editorial board for their outstanding efforts. Your Journal team works hard to bring you the best research in our field. If you will be at the SRA International annual meeting in Vancouver, British Columbia in October 2017, please consider attending the no-cost, Journal-provided learning lab, *Stepping Stones to Becoming a Peer-Reviewed Journal Author*. This three-hour lab will

provide participants with an overview of the *Journal's* peer-review process and how to prepare a manuscript. This will be on the morning of Sunday, October 15, 2017. Additionally, the *Journal* will offer a no-cost webinar on scholarly writing on March 9, 2017. Please send an email to the address below if you would like more information. Finally, if you are a non-SRAI member and wish to have the *Journal* delivered to you via email, please send a message with your name and institution to journal@srainternational.org.

ARTICLES

Using Competencies to Transform Clinical Research Job Classifications

Rebecca Namenek Brouwer
Duke University

Christine Deeter
Duke University

Deborah Hannah
Duke University

Terry Ainsworth
Duke University

Catherine Mullen
Duke University

Betsy Hames
Duke University

Heather Gaudaur
Duke University

Tara McKellar
Duke University

Denise C. Snyder
Duke University

Abstract: *The field of clinical research has changed considerably in the past 20 years. As the work in this realm has come to embody far more than the pursuit of improved patient care, this has meant that staff supporting the research are asked to take on additional responsibilities, learn new processes, and be continuously educated on modernized policies and procedures. To address the increased responsibilities and complexities of work, Duke University School of Medicine leadership agreed that an overhaul of job descriptions for clinical research professionals was needed. A working group was created, assembling administrative leaders, human resources professionals, and clinical research subject matter experts. The Clinical Research Professionals Working Group (CRPWG) aimed to simplify the number of job classifications at Duke from approximately 80 to 12 and utilize a competency-based approach to professionalize the clinical research professionals working environment. The Joint Task Force for Clinical Trials Competency (JTFCTC) developed draft competencies*

that were used as the foundation to develop a tool that helped define job descriptions and map incumbent employees into the new jobs. Almost 600 employees were mapped using the competency-based tool. This paper describes the processes used to develop the competency-based tool and map incumbents, and provides the results and lessons learned of the mapping. A strong workforce of clinical research professionals will enable higher quality research and ultimately lead to better patient care and health outcomes.

Keywords: *Competency, clinical research, workforce*

Acknowledgments

The authors would like to acknowledge funding for this initiative from Duke's CTSA grant UL1TR001117, as well as contribution and leadership from the following individuals: Mark Stacy, Billy Newton, David Smithwick, Andrea Doughty, Mary Smith, Angie Cain, Leigh Burgess, Rebecca Moen, and the countless research professionals that contributed to this work.

Problem Statement

The role of the clinical research professional has evolved substantially in the past 20 years due in large part to the ever-changing field of clinical research. The regulatory requirements have grown and responsibilities multiply to keep pace with the shifting research landscape (Johnson, 2013). This results in additional burden for investigators and study teams. Changes in the past 20 years have created the new environment in which clinical research is conducted. The emergence of the electronic medical record has required research staff to learn new documentation practices and policies. The executive order signed by President Bill Clinton in 2000 allowed for payment of standard of care research, however, this National Coverage Determination added layers of complexity around payments. The proliferation of international trials introduced additional complexity around site and study management, an understanding of laws, and tedious communication. HIPAA requires staff to have a deeper understanding of privacy concerns and ethics in research. From FY 2003 to 2013, the National Institutes of Health (NIH) effectively lost 22% of its capacity to fund research, creating greater pressure for clinician scientists to secure external support to pay for their research (National Academies of Sciences, Engineering & Medicine, 2016).

As the work in clinical research has come to embody far more than the pursuit of improved patient care, this has meant that staff supporting the research are asked to go farther than simply recruiting participants into studies and ensuring study visits and interventions occur as intended. While job responsibilities and roles may have changed rapidly, the job descriptions and classifications held by individuals performing the tasks have not (Stevens & Daemen, 2015). In addition, training demands and resources for development have soared (Speicher et al., 2012). To address the increased responsibilities and complexities of work, Duke University School of Medicine leadership agreed that an overhaul of job descriptions for clinical research professionals was needed. Job descriptions related to clinical research at the institution had not been updated in more than fifty years. However, a simple "update" of the jobs was not enough; instead, a deep

dive was pursued with an intensive review from a focused workgroup representative of many stakeholder groups, and engagement across the institution for departments, centers, institutes, faculty, staff and administrators who may potentially be impacted. The workgroup reviewed literature, researched options and existing models in the field with clinical research professional organizations and participated in CTSA activities before choosing a competency-based model (Sonstein et al., 2014). This is consistent with other fields, where competency models are adopted to ensure readiness of the workforce, and assess skills needed for appropriate conduct of a specific job (O'Neil, 2014).

There is a need to professionalize the research professional workforce in order to continue to produce high quality clinical research. This means that those involved in clinical research need to ensure that the roles we are asking staff to fill are 1) well-articulated, 2) competency-based, 3) appropriately matched to experience and educational level, and 4) have descriptions that are updated frequently to keep up with the shifting landscape. In an attempt to do just that, Duke University undertook a large effort to revise job classifications for research professionals. Below, we describe the steps taken towards professionalizing the workforce in this large academic medical center.

Observations and Methods

Formation of a working group

Human Resources departments within institutions cannot take on a transformation like this on their own as they may not have the subject matter expertise. Therefore, for the purposes of refining job classifications at Duke, the multidisciplinary Clinical Research Professionals Working Group (CRPWG) was formed. This group included those who have grown up in the field of clinical research for over twenty years, representatives from Human Resources (corporate, school, and department levels), and administrators key to the clinical research enterprise. The group was relatively stable, with approximately 10 participants who have remained very engaged in the process over a three-year period. The group convened every 2-3 weeks, and tackled assignments in between meetings. Process and implementation was driven by a core group in the institution's central clinical research support office (known as the Duke Office of Clinical Research; (Snyder et al., 2016)).

Importantly, the workgroup was committed to transparency and engagement within the research community. This was facilitated by the creation of a wiki page, which was visible to the School of Medicine, and was updated roughly once a week, with draft documents available for review. Workgroup members frequently presented to the research community in order to address concerns, (see engagement below). We requested feedback in a variety of venues, and incorporated suggested edits to the plan when appropriate. The group ensured that throughout the process, the research community had a voice and an opportunity to participate in shaping the long-term vision.

Finally, our group connected frequently with contacts at other institutions working on similar initiatives. Members of our committee took part in meetings with other Clinical and Translational Science Award consortium members about the supplement "Enhancing Clinical Research Professionals' Training and Qualifications," which aims to improve the safety, efficiency, and quality of clinical trials by establishing standardized educational competencies and training across the CTSA Consortium. Our committee members who worked with this group assisted with the refinement of competencies in several domain areas.

Stakeholder engagement

Key to the success of the initiative is frequent and true engagement with a variety of stakeholders. The CRPWG engaged groups in three general realms: Administrative leaders, faculty, and the research community. The message threaded through conversations with each group is that the long-term investment in this workforce is important on many levels – 1) at the employee level: the initiative encourages equity and fairness to employees and allows employees to better understand career progression as it is tied to competencies; 2) at the institutional level: the initiative reduces risk by identifying competencies associated with job responsibilities and ensuring quality training; it also "raises the bar" for our workforce, allowing us to attract and retain higher quality research professionals through the development of a research career ladder; and 3) at the workforce level: while hiring and training higher performing individuals, we can expect better performance, and higher quality research.

With administrative leaders, the focus of the CRPWG was on messaging and frequent updates. Careful consideration was given to the potential impact on our institution, including financial impact, and how best to handle employee and departmental concerns about the change. Engagement was ongoing via brief email communications, but also via regularly scheduled face-to-face meetings.

The CRPWG engaged a faculty advisory committee, a group of clinician-scientists from a variety of disciplines who are actively involved in clinical research activities. These faculty advisors were selected as they are invested in the future of the field and the institution, and have teams that are considered high-performing. The CRPWG aimed to get these faculty members' perspectives on how this initiative would affect their study teams and research projects. Faculty advisors allowed their teams to participate in a mock mapping exercise. At the completion of the mock mapping, faculty and their senior managers gave critical, candid feedback that was incorporated into our final processes.

Perhaps the most robust and important group of stakeholders engaged in the process were the research professionals themselves. These are the same individuals who would be affected by the changes. This community was invited to take part in the process in a variety of ways. First, the Research Professional's Network (RPN), which is open to all research professionals, offers networking/professional growth opportunities and at the time of the mapping included approximately 400 individuals. These employees engaged in the initial roll-out and evaluation

of the proposed model (see below), development of competencies for the various competency domains, and received summary updates in the network's e-communication. Secondly, a central listserv of research professionals (approximately 7,000 people) was used to communicate updates in the process and invite participation in the RPN events. Third, we leveraged Duke's clinical research structure to engage leaders within each of our eighteen Clinical Research Units (CRUs). CRUs are the clinical research scientific and administrative unit for Departments, Centers and Institutes). These leaders were updated about the initiative at biweekly meetings, and were encouraged to invite CRPWG members to speak to their research professional staff about the initiative.

All feedback from stakeholder meetings was brought back to regular CRPWG meetings. In short, the engagement at multiple levels was a crucial, yet time-consuming component, of this important initiative.

Derive a model

At Duke, the number of titles held by personnel in jobs with clinical research responsibilities had become unmanageable. This caused issues related to equity across the organization, and created an inability to understand the composition of our research professional workforce. For these reasons, the CRPWG aimed to simplify the number of job classifications/descriptions from approximately 80 to 12. Job classifications were grouped into a few broad categories, based on general job functions. Clinical Research Specialist (and Sr.) positions are focused on supporting clinical research teams or performing less complex tasks involved in executing research studies. Regulatory coordinator (and Sr.) positions are specialized in the area of research regulation. Clinical Research Coordinator (and Sr.) and Clinical Research Nurse Coordinator (and Sr.) positions are responsible for participating or leading the day-to-day operations of clinical research studies (nurses will also participate in clinical activities associated with research). The Research Practice Manager (and assistants) have larger responsibilities associated with oversight of clinical research activities within specific therapeutically-aligned units. And finally, the Research Program Leader (and Sr.) positions manage day-to-day operations of clinical research activities but have additional leadership responsibilities in the areas of program and portfolio management. Figure 1 depicts the model.

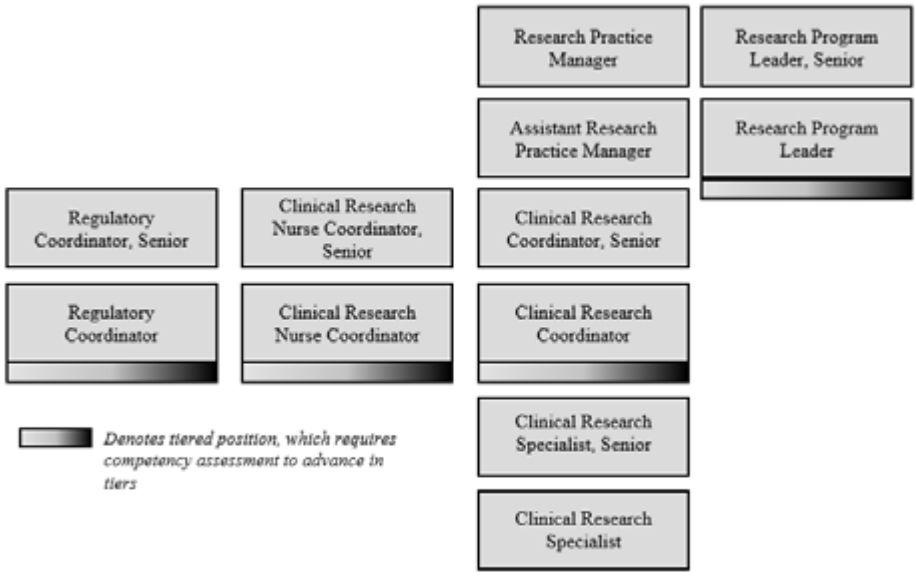

Figure 1. Clinical Research Professionals Working Group competency-based framework for job classifications.

Notable in our model is the concept of tiered positions. Positions marked with a gradient band under the same title would be treated differently than the others. In these positions, there would be multiple tiers, with each tier associated with different levels of competency in various domains (see below on competencies). In order to move between tiers, the employee must exhibit the competencies associated with that tier. Employees have two opportunities per year to move to the next tier, and manager endorsement is required (see below on implementation for more details). A major benefit of the tiered system is that it allows for employee growth (with associated compensation) without the need to reclassify positions—a historically burdensome HR process.

This proposed model was presented to various stakeholders, and a stoplight evaluation was conducted with 175 staff. Community members were asked to select either a green light (no major concerns) or red light (major concerns, with reasoning behind the concern) for 10 items. This included the appropriateness of 1) name, 2) minimum education, and 3) minimum experience requirements for each position; the inclusion of tiers for some positions; and the number of titles. The feedback we received was that all proposed elements of the plan exceeded the green light threshold of 80%; however, the final name of some titles were adjusted based on comments.

Competencies drive the framework

Competencies guide the work of professionals within many health-related fields (Melnyk, Gallagher-Ford, Long, & Fineout-Overholt, 2014), but the concept is much newer as applied to clinical research staff. In 2014, the notion of employing competencies for research professionals began taking hold. Steven Sonstein, in his presentation "Moving from Compliance to Competency: A Harmonized Core Competency Framework for the Clinical Research Professional" articulated the concept, which was being driven by the Joint Task Force for Clinical Trials Competency (Sonstein et al., 2014). The thought is to utilize competencies, which can be grouped into high-level conceptual domains, as a way to build a framework that can be used in a variety of situations. Certainly, in workforce training, the competencies can better define performance criteria and aid designers in matching training opportunities to measurable outcomes (Jones et al., 2012). Similarly, these competencies can create the foundation of standardized job descriptions for professionals engaged in the field of clinical research.

The JTFCTC developed draft competencies that were used as a starting point. Our CRPWG took JTFCTC as base competencies, and then worked in pairs to edit the competencies under each of the eight domains: 1) Scientific Concepts and Research Design, 2) Ethical Considerations, Patient Care and Safety, 3) Medicines Development and Regulation, 4) Clinical Trials Operations (GCPs), 5) Study and Site Management, 6) Data Management and Informatics, 7) Leadership and Professionalism, and 8) Teamwork and Communication. Edits were made to make the competencies more specific to our academic medical center (AMC), and more broadly encompass social/behavioral studies. Ultimately, the third domain (Medicines Development and Regulation) had fewer competencies relevant to staff and was merged with Domain 4 to yield 7 domains for clinical research staff.

Once revised competencies were established, the CRPWG worked to create a tool that described levels for each competency. Each level was assigned a number (1, 2, 3, 3.5, 4, or 5) that corresponded to specific job descriptions. Those competency levels assigned a 1 would be responsibilities included the Clinical Research Specialist (CRS) job description; those with a 2 would be found in the CRS Senior; those with a 3 or 3.5 would be found in our tiered CRC, CRNC, or Regulatory Coordinator positions (3 representing responsibilities associated with the lower part of the tier, 3.5 the higher), 4 was associated with CRNC Senior, CRC Senior, and RPL positions, and 5 was typically associated with our ARPM/RPM/RPL Senior level positions. Versions of Bloom's taxonomy (Anderson & Sosniak, 1994) were used to guide the workgroup as they worded the competencies. This allowed them to underscore that movement through the competency levels involves not just increasing experience level—instead, it requires the employee to develop deeper critical thinking skills, and move along the continuum from simple to complex tasks.

This tool would eventually be used to map our incumbent staff and serve as a basis for additional functions such as developing job descriptions, conducting performance evaluations, and training.

Table 1. Sample of leveled competencies.

Research Operations Domain **Competency 1:** Screening for potential eligibility	Identify participants that meet eligibility requirements under the supervision of a CRC/CRNC. Document in record. Screen participants for minimal risk studies independently and document in record. May screen participants for studies with greater than minimal risk, under supervision. Screen participants for all studies independently. Screen participants independently and provide oversight and training to study team members who screen participants. Provide oversight and training to entire unit or department with regards to subject screening. Set up unit-wide systems, policies related to subject screening.

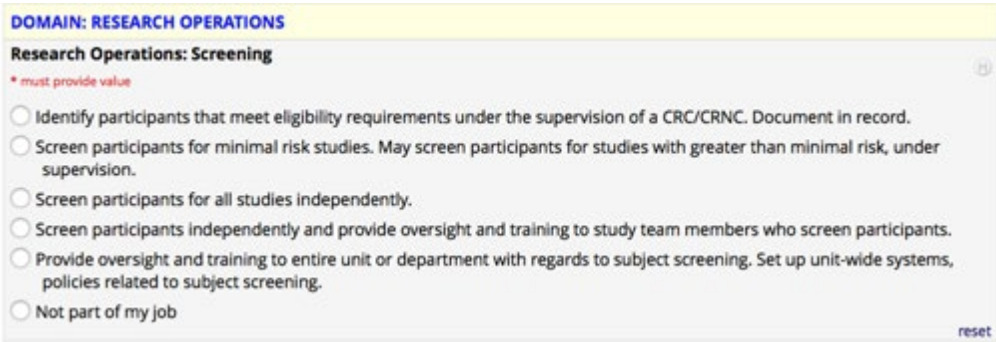

Figure 2. Mapping tool for employees.

Development of job descriptions

Job descriptions for clinical research professionals at Duke have remained relatively constant for fifty years. Comments from research staff and managers suggested that it was difficult to tell positions apart—for example, the junior level clinical research coordinator description looked very much like the senior level. The descriptions employed somewhat vague terminology and therefore left much room for interpretation by managers and staff. This led to progress through levels being driven primarily by number of years in the position, not by increasing competency.

The revised descriptions were designed to bring greater clarity to the job responsibilities for each position, and provide a clear path for career progression. The job descriptions were structured under the seven competency domains described above. Each competency level was described clearly underneath each domain. The differences between job descriptions became much clearer. For example, the Clinical Research Coordinator (CRC) job description may describe the responsibility for screening as "Screen participants for all studies independently." The next level position, CRC Senior, clearly denotes that the level of responsibility related to screening is higher—and does so via distinguishing fonts: "Screen participants for all studies independently **and provide oversight and training to study team members who screen participants**." Here, the differentiation between levels of responsibilities with regard to screening is definitive.

The working group developed job descriptions in collaboration with staff currently in equivalent positions as well as with those who were recently reclassified in the pilot mapping process. Feedback from the community was overwhelmingly positive about how the job descriptions were structured.

Implementation

Pilot process

Once the working group had completed the first version of the model and draft job descriptions with associated competency levels, they worked to test the process by mapping a pilot group of staff. Sixty staff members were identified in the pilot units.

The mock process, which evolved into the foundation for our final mapping process, included the following elements:

1) **Request packet of information from research unit head**. We asked the unit leaders to provide a) an organizational chart including all research staff, b) CVs from each staff member to be mapped (with months/years of each position articulated), and c) job descriptions from each staff member.
2) **Employee completes questionnaire about their job responsibilities**. Once the packet was received, each research staff member was sent a link to a REDCap™ survey tool to complete. All data for this initiative were collected and managed using REDCap electronic data capture tools hosted at Duke University. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources (Harris et al., 2009). This specific use of the REDCap™ tool asked each employee to provide basic information about employment (name, unit, current position), and then asked them to select the level of responsibility associated with each competency (Figure 3). Again, the competencies were arranged by domain. Employees could also indicate that the competency was

not a part of their job, and add comments to describe other duties not included in the questionnaire. The employee then recorded the name and email address of their manager. The form automatically routed to the manager. This form took approximately thirty minutes to complete.

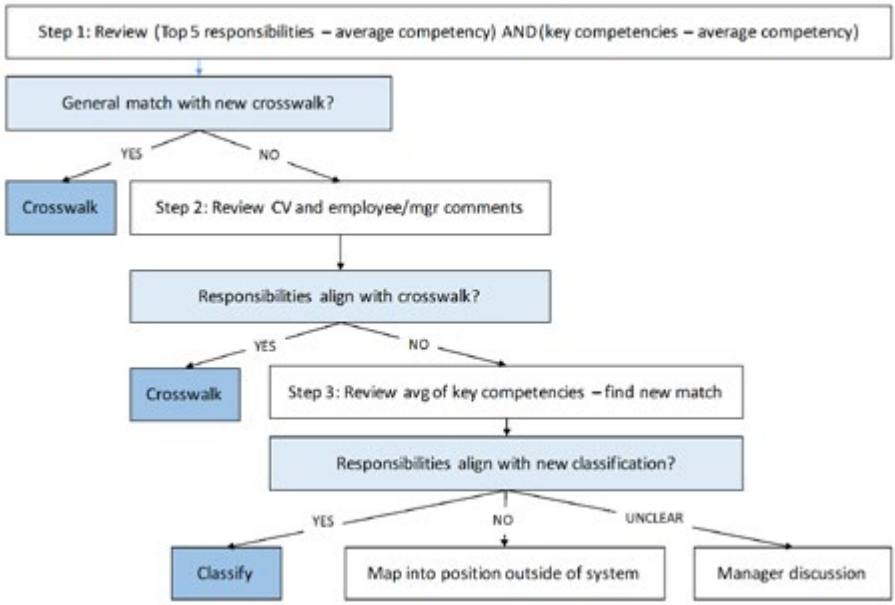

Figure 3. Process used for mapping incumbent staff.

3) **Manager reviews employee questionnaire**. The manager received a link via email with a subject line of "Please review job classification tool for your employee, [first name] [last name]." The manager reviewed the employee's response to each item and if s/he felt that it did not appropriately represent the level of competency, the manager had the option to edit the field. The manager had the opportunity to add comments, and once the survey was complete, the working group was notified via automated email. A copy of this tool's data dictionary is available upon request.

4) **A summary report is created**. The information from the REDCapTM tool was exported and then mail merged into a summary report. The report provided basic information about the employee, and displayed the manager's report of the employee responsibilities (each responsibility rated as 1, 2, 3, 3.5, 4, 5 or 0 if not part of the job), as well as an indicator of the magnitude of discrepancy between the employee and manager report. For example, a magnitude of 1 indicated that the employee thought he/she was one level higher on one competency than the manager reported. A magnitude of -8 indicated that the manager believed the employee was one level higher in 8 competencies

(or 2 levels higher in 4, etc.). All raw data from employee and manager were available if further review was needed.

5) **Map to new classification**. The reports, CV, and job descriptions were reviewed by the committee to map employees into the new classifications. The summary report, derived from the job responsibility tool, drove the discussion. In general, a report that displayed many of the same numbers would suggest a good match with the job description associated with that number (for example, many 3's likely suggest a CRC title). The review of these documents was conducted by at least two members of the working group. This process was not intended to provide employees with a promotion or to be utilized as corrective action, but rather to be reflective of the competencies they display in their daily job. Any employee that could not easily be mapped into a new description was marked for further discussion with the unit manager and medical director.

6) **Meet with unit leaders to review results**. The results of the mapping process were shared with the faculty leaders and their staff leads. During a one-hour meeting, the committee members reviewed the process utilized to determine the classification for each employee and reviewed the results.

Final mapping

The pilot process described above worked well and was utilized, with only small changes, with our full cohort of approximately seven hundred clinical research staff. The committee opted to make a few edits to the REDCap™ tool so the summary report was more useful. We eliminated the employee's report of percentage of time spent in each activity since we found that they had a very difficult time accurately reporting this information, and it was of little use to our committee members. We instead asked employees to list their top 5 responsibilities and we eliminated the request for the employee job description since it overlapped considerably with the information provided in the tool and CV.

The committee members reviewed, in pairs, each unit's clinical research staff using the process depicted in Figure 4.

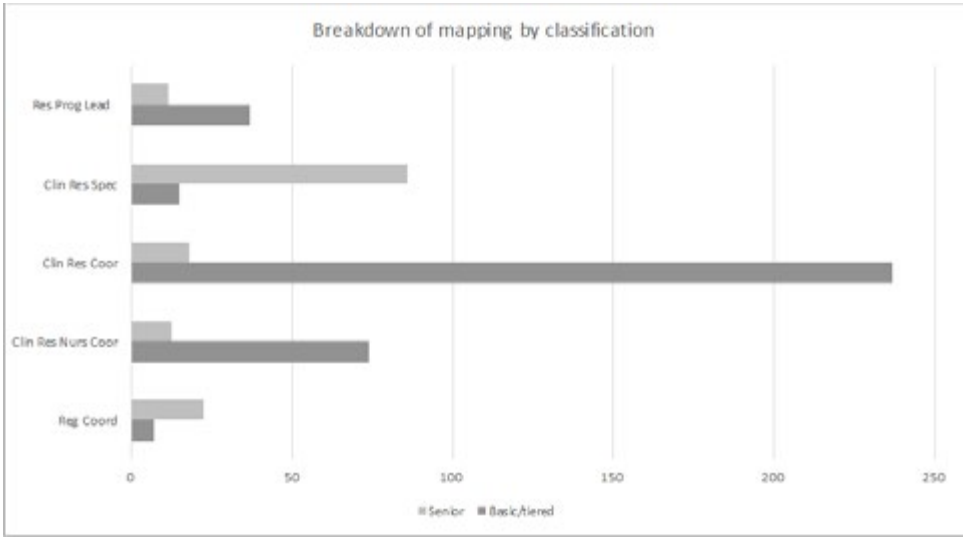

Figure 4. Breakdown of mapping by classification.

In the final mapping process, 589 employees had their REDCap tool information reviewed by the committee, of which 32 were determined to require classifications that fell outside of the clinical research structure. Figure 4 depicts how the 557 remaining employees mapped into the various new titles. Of those that were mapped, 15.6% were mapped into a higher level position than their previous classification, and 0.5% position were mapped into a lower position. 83.9% moved into an equivalent position.

Figure 5. Timeline of Clinical Research Professionals Working Group activities.

Reflection

The work of the initiative thus far has been focused on improving the job classifications for research professionals by using a competency-based framework; however, the initiative has always been intended to extend simply beyond job descriptions.

With the competencies well-established, the committee will use them for several related initiatives, with information available for other institutions found here: https://medschool.duke.edu/research/clinical-and-translational-research/duke-office-clinical-research/about-clinical-research-and-navigating-research-duke/staffing-clinical-research :

1. A tool to match responsibilities to title and derive a job description. A survey, based on the REDCap tool created for the mapping process, has been developed so hiring managers can select the competencies expected of their upcoming new hire. The results of the hiring manager's responses are manually reviewed by committee members to derive a title, which is provided to the hiring manager and central HR recruiter, and a job description is generated. This ensures that competencies are used consistently when seeking new staff. The team has developed a pilot process, which has been used to select over 100 new positions, and is working to automate this process in the coming year.
2. Assessment of competencies. As employees work to move through the tiers, their competency level in each domain will need to be assessed. The committee has derived objective assessments of key competencies that can be managed centrally or by trained managers.
3. Performance evaluation tool. Now that competencies are well-established, managers have asked to use them in the context of performance appraisals. The CRPWG will be working with HR in the coming year to incorporate competencies into the formal performance evaluation process.

While those in other professions have been considering the use of competencies for career structure in a broad sense, (Furtado et al., 2015), when the Clinical Research Professionals Working Group first convened, we were likely the first to apply the competencies to staff within an academic medical center. The initiative required a strong collaboration between a centralized research support office (Snyder et al., 2016), institutional leadership, and a variety of professionals in human resources, and required a significant amount of time and effort.

This work follows that of others who have successfully used competency frameworks to improve their workforce (e.g., Glover & Frounfelker, 2013; Hoge, Tondora, & Marrelli, 2005). Duke anticipates that this competency-based framework will allow us to enhance the professionalism and competency of its workforce. A strong workforce will enable higher quality research and ultimately better patient care and health outcomes.

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Protecting the Teaching and Learning Environment: A Hybrid Model for Human Subject Research Public Policy Implementation

Kristi N. Hottenstein, Ph.D.
University of Michigan-Flint

Abstract: *Regulations for research involving human subjects have long been a critical issue in higher education. Federal public policy for research involving human subjects impacts institutions of higher education by requiring all federally funded research to be passed by an Institutional Review Board (IRB). Undergraduate research is no exception. Given the literature on the benefits of undergraduate research to students, faculty, and institutions, how human subject research public policy is being implemented at the undergraduate level was a significant gap in the literature because how these public policies are implemented impacts undergraduate research. This qualitative, single-case study examined the human subject research policies and practices of a selective, Mid-western, Council on Undergraduate Research institution. The purpose of the study was to determine how this institution implemented human subject research public policy to benefit its students. This institution used a hybrid approach of public policy implementation that met federal requirements while capitalizing on the role local actors can play in the implementation process. This model resulted in a student-friendly implementation emphasizing various learning outcomes and student mentoring. Although there is considerable research and public discussion on the negative aspects of IRBs, if approached in a manner that embraces student learning, the IRB experience can be an extremely beneficial aspect of the institution's learning environment.*

Keywords: *Undergraduate research, institutional review board, public policy, human subject research*

Introduction

Concern over the impact federal regulations have on the internal affairs of higher education institutions remains a critical issue in higher education (Dash, 2007; Feeley, 2007; Hemmings, 2006; Jaschik, 2008; Stark, 2012; White, 2007). Protection of human subjects is one area that the Federal government has promulgated policy through its agencies to influence higher education policy and action at the institutional level. Federal public policy for research involving human subjects, better known as the Common Rule, impacts higher education institutions by requiring all federally funded research to be passed by an institutional review board. The influences of this federal policy determine institutional and faculty ability to gain access to federal research funds (U.S. Department of Health and Human Services, 1999). In light of the value of undergraduate research to colleges and universities, one would have expected to find studies that examined the relationship between the institutional review board and undergraduate research. Unfortunately, these types of studies do not exist.

Undergraduate Research

Undergraduate research benefits students, faculty, and institutions. Student benefits include: increases in retention, intellectual gains, skill attainment, graduate school placement and career preparation (Crowe & Brakke, 2008; Hathaway, Nagda, & Gregerman, 2002; Ishiyama, 2002). Faculty benefits include: increased lab assistance, ongoing research opportunities, and assistance with tenure and promotion (Corley, 2013; Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998). Institutional benefits include: increased admissions selectivity, increased institutional funding, and lower attrition rates (Kierniesky, 2005; Nagda, et al., 1998). In 1998, *Reinventing Undergraduate Education: A Blueprint for America's Research Universities* was published by the Boyer Commission on Educating Undergraduates in the Research University. The report called for increased involvement of undergraduates in faculty-mentored research experiences. This led to increased funding through the National Science Foundation, the National Institutes of Health, and the Howard Hughes Medical Institute to support American colleges and universities in creating opportunities for authentic research experiences for undergraduate students across multiple disciplines (Adedokun, Carleton Parker, Bessenbacher, Childress, & Daniels Burgess, 2012; Hunter, Laursen, & Seymour, 2006).

In 2002, The Association of American Colleges and Universities advocated for additional attention on undergraduate research calling it a key means to engage students, and in its 2007 *College Learning for the New Global Century* report, it recommended undergraduate research as a key focus area. In 2005, National Survey of Student Engagement included undergraduate research as an indicator for effective teaching (Corley, 2013). Kuh (2008) listed undergraduate research as one of ten high-impact educational practices beneficial to students and Lopatto (2006) discussed how undergraduate research engages students in active learning, provides academic challenge, and creates student-faculty interaction in ways that meet student engagement benchmarks reflected in the National Survey on Student Engagement (NSSE). The literature reflects a multitude of well-researched benefits of undergraduate research as well as a call for institutions to increased involvement in undergraduate research. Given this, it is important to understand the policies that regulate undergraduate research. Most notably, undergraduate research, as with all human subjects research conducted on the campuses of American colleges and universities, requires institutional review board approval and monitoring.

Institutional Review Boards

In 2008, there were more than 5,500 IRBs nationwide providing oversight to any federally funded project, and a large amount of unfunded research (Sanders & Ballengee-Morris, 2008). In a published report titled *Research on Human Subjects: Academic Freedom and the Institutional Review Board*, the American Association of University Professors (2006) spoke out strongly against IRB policies and practices stating, "there could hardly be a more obvious potential threat to academic freedom" (p. 1). Stark (2007) argued that the regulations aimed to protect the rights of human subjects actually violated the rights of researchers. Furthermore, some research indicated a handful of isolated, unethical practices may have created a spiral of knee-jerk reactions resulting in a loss of academic freedom, and a laundry list of other problems for researchers

(White, 2007). The Office of Human Research Protection database now contains over 10,500 records of registered IRBs (U.S. Department of Health and Human Services, 2016).

The basic provisions of the FCR Title 45 Part 46, better known as the Common Rule, were written in such a way that allowed for institutional interpretation and discretion. Institutional discretion impacts how the regulations are actually implemented at the institution. The literature reviewed reflected a variety of different interpretations of this Federal policy, as well as a variety of different implementation models being used to carry out federal human subject research public policy at the institutional level.

It appears institutional review boards are a permanent part of higher education. If undergraduate research truly is the pedagogy of the 21st century, more disciplines, departments, and researchers will find their research going before IRBs. Understanding how IRBs are implementing human subject research public policy is beneficial to researchers, institutions, and IRBs. First, it assists other institutions in examining their IRB implementation strategies and practices and can help them implement best practices. Understanding how a Council on Undergraduate Research institution is implementing human subject research public policy for undergraduate research may help to shape future policy on the issue. Research on the IRB role and function as it pertains to the implementation of Federal regulations clarifies IRB scope of practice, and a clearly defined scope of practice can help to inform researchers on ethical practices. Lastly, providing stakeholders (faculty, staff, and students) with a clearer understanding of how IRBs are implementing human subject research public policy can aid in alleviating some of the contention that is so prevalent in the literature.

Policy Implementation Theory

I approached this research through a public policy implementation theory lens. Public policy implementation was one of the earliest topics addressed by policy analysts. The implementation of policy is not a uniform process. Implementation varies by policy type, each type possessing a different degree of implementation difficulty. Although regulatory policies such as the Common Rule may seek harmony, an entity, in this case higher education, affected by the policy can be contentious (deLeon & deLeon, 2002). This contention was evident throughout the literature reviewed.

Policy implementation theories can be broadly categorized into three groups: top-down theories, bottom-up theories, and hybrid theories. Top-down approaches are based on the premise that implementation of policy begins with a decision made by government. Top-down theories disregard the impact of implementers (Pulzl & Trieb, 2007). Bottom-up approaches take a counter approach to policy implementation, emphasizing the role of local actors in the policy implementation process, noting the importance of those actually involved with delivering the policy. As researchers developed and analyzed the pros and cons of top-down and bottom-up approaches, hybrid theories of implementation emerged. Top-down and bottom-up scholars

agreed policy implementation is "a continuum located between central guidance and local autonomy" (Pulzl & Trieb, 2007, p. 100). Hybrid models mold the relevant aspects of both approaches into a middle ground. Hybrid models understand the importance of top-down aspects such as centrally defined policy decision, but also appreciate and value the need to involve lower-level actors.

Ripley's Model of the Policy Process

Randall Ripley is a public policy theorist known for his hybrid approach to the public policy process. Ripley's approach highlights the connections between the environment, governmental policy activity, social policy activity, and the political actors' perceptions of the environment. Using Ripley's (2010) conceptual model, I identified the environment as the institution, the policy actors as the IRB chair, IRB members, and undergraduate research advisors/mentors, the governmental policy activity as the federal policy to protect human subjects, and the social policy activity as undergraduate research. Figure 1 below illustrates how Ripley's model can be adapted to inform the implementation of human subject research public policy implementation at the institutional level.

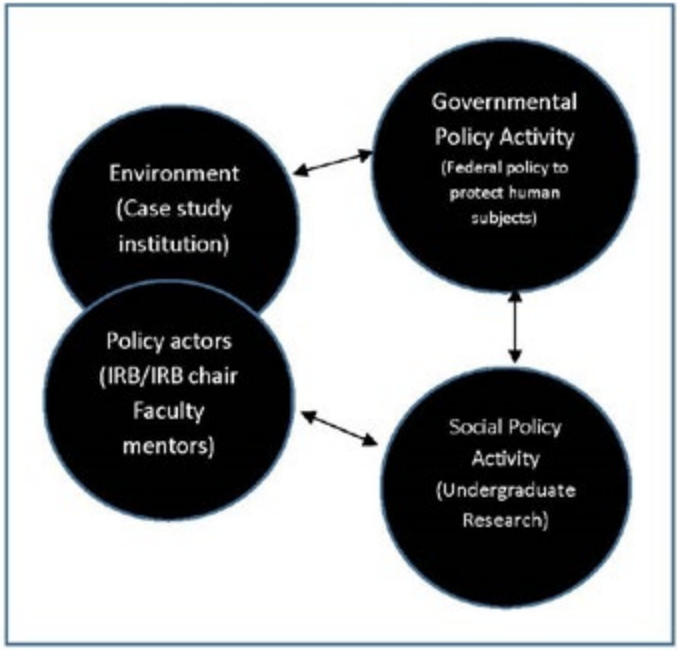

Figure 1. Illustration of how Ripley's model was applied to analyze human subject research public policy implementation at the institutional (Adapted from Ripley's General Model, 2010).

Theme-Centered versus Project-Centered

This study examined the implementation of a Federal protective, regulatory policy at the institutional level, specifically, federal human subject research public policy as defined in the Code of Federal Regulations, Title 45, Part 46. Purposeful sampling was used by the researcher to select the case study institution. Some scripters have been modified in an attempt to provide anonymity to the institution. For the purposes of anonymity, the selected institution will be referred to throughout the remainder of this document by the pseudonym, MRC. MRC is a selective, Midwestern, Council on Undergraduate Research affiliated institution, intensely focused on undergraduate research.

The methodology was a qualitative, single-case study. Semi-structured interviews and methodological triangulation were used to gather data which was then analyzed using NVivo 11 qualitative software. While the literature review covered undergraduate research and IRBs respectively, a significant gap in the literature existed as to how federal human subject research regulations were being implemented at the undergraduate level. Taking an in-depth look at how these regulations are implemented by an IRB at a CUR institution where undergraduate research is a significant portion of the undergraduate experience has helped us to better understand this connection.

Findings

The literature reviewed for this case study presented arguments for the value of a quality undergraduate research program. From high impact best practices, to the pedagogy of the 21st century, to increased job and graduate school placement rates, the arguments for a quality undergraduate research program were abundant. The purpose of this study was to determine how one institution has implemented human subject research public policy to benefit its students.

Four main themes, some with subsequent subthemes, emerged from the data. Figure 2 below illustrates the themes and subthemes found.

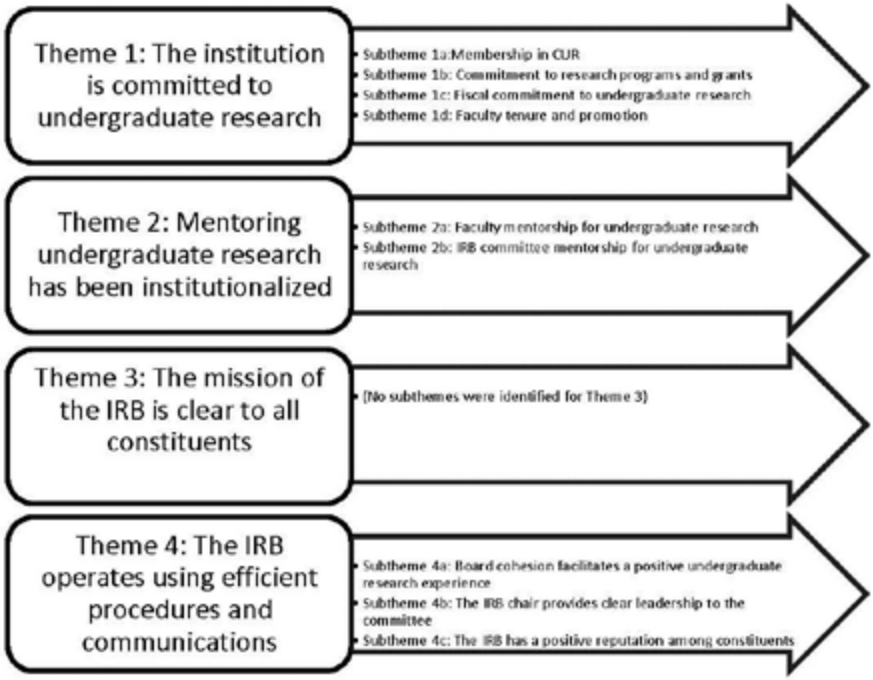

Figure 2. Figure 2 is a visual illustration of the findings broken down into themes and subthemes

Implications for federal public policy implementation

By and large, most public policy implementation theories were created during the 1970's and 1980's, over 40 years ago (Pulzl & Trieb, 2007) and may be viewed as not applicable or outdated. While Ripley created his General Model for Policy Process to be broad enough to apply to all stages of the policy process, it can also be applied specifically to any one stage of the process, in this case, the policy implementation stage.

Amidst numerous outdated implementation theories, lies a hybrid model for general policy process, that when applied specifically to the implementation stage, can inform and describe policy implementation (Ripley, 2010). The idea that the implementation of human subject research public policy is best done using a hybrid approach may be the most significant finding of the study. What is outlined in the federal code of regulations is the same for every institution, but every institution is using their own discretion, their own perceptions, their own environmental factors, and their own actors to implement this public policy in a slightly different way. Ripley was right to identify the four major components within his model (governmental policy activity,

social policy activity, policy actors, and environment), but what his model was missing, and what this study shows, is that the power of these components are not equal at the implementation stage.

The implementation of federal human subject research public policy at MRC occurred using a hybrid approach. While human subject research public policy was created using a top-down model from the Federal government, MRC chose to implement federal policy using a hybrid model of implementation that meets federal requirements, while capitalizing on the role the local actors can play in the implementation process. This model has resulted in a student- and faculty-friendly implementation emphasizing various learning outcomes and student mentoring, all while adhering to federal level requirements.

The findings of this case study are associated with various components of Ripley's model. I confirmed that policy actors at MRC, including the IRB members, and most notably the IRB chair, create and carry out policies in conjunction with the institution's mission and culture. MRC's policies and processes protect human subjects, but also protect the teaching and learning environment, and support undergraduate research and student learning. Environmental factors such as the institution's commitment to undergraduate research and the fact that mentoring undergraduate research at MRC has been institutionalized, has, and continues to, impact how the IRB (the actors) implement policies. According to Ripley's model (2010) the environment and the policy actors are intertwined with regards to policy implementation. They impact each other, and together, they impact both government and social policy activity. I found this to be true at MRC.

As the IRB members and chair, along with other key political actors, including faculty mentors, the administration, and the summer research program director, carry out the day-to-day decisions, it was clear they do so with best practices for undergraduate research and student learning in mind. For example, the summer research program committee rejects very few applications. On average, only 8% of first round applications were outright rejected, while 32% were sent back for revisions. Additionally, the summer research director personally calls or emails the faculty mentors of the students whose proposals need revisions, in order to communicate what is necessary for approval.

While the summer research program rejects only a small percentage of annual proposals, the IRB does not outright reject proposals at all. In fact, if an IRB proposal is not approved as is, the IRB chair personally calls the student researcher into their office and discusses what changes need to be made to move forward. The IRB chair also calls the faculty mentor to ensure they are aware of the necessary changes as well. It was evident during interviews that this personal approach to communicating necessary changes was both appreciated and valued by both students and faculty mentors. Every element of the research provided evidence that undergraduate research was woven into the fabric of MRC. In fact, the summer research director at MRC referred to undergraduate research as the institution's "stitch" and called undergraduate research an "institutional priority" (Personal communication, July 8, 2015).

While four main themes emerged from the research, it is important to note that these themes were not mutually exclusive. The implementation of IRB policy is intimately intertwined within the culture that is this undergraduate research focused institution. Many of the ways this college

is committed to undergraduate research and the protection of human subjects also help to institutionalize the idea of undergraduate research at the institution. For example, MRC has a day-long research symposium. This event not only shows the College's commitment to undergraduate research but institutionalizes undergraduate research at the College by having a dedicated day of no classes built into the academic calendar so student research can be highlighted.

Recommendations

Institutions that want to have rich undergraduate research experiences should adopt a hybrid approach to public policy implementation that ensures Federal public policy is being adhered to, but does so in a way that encourages and embraces student research. Although there is considerable literature and public discussion about the negative aspects of IRBs, if approached in a manner that embraces student learning, this study supports the notion that the IRB experience can be an extremely beneficial part of the institution's learning environment. Kuh (2008) listed undergraduate research as one of ten high-impact practices that benefit students. Research indicated positive undergraduate research experiences can impact retention in a very positive way (Ishiyama, 2001). The IRB process is a part of that high impact experience, thus institutions should be mindful of how human subject research public policy is being implemented.

I found Ripley's General Model for Policy Process applicable specifically to the implementation stage. Ripley's model was created for broad use and thus many would not consider using his model specifically for implementation. This is unfortunate because I found his model to be very adaptable, and his hybrid approach very informative to my research. Additional research to validate Ripley's model's applicability to public policy implementation analysis is strongly recommended.

Conclusions

Chadwick and Dunn (2000) sum up the last 50 years of IRB evolution by saying, "like many highway projects, the IRB system was sound when it was designed, but became out-of-date and overloaded almost from the start" (p. 21). IRBs are often viewed as authoritarian in nature and working against, instead of in collaboration with, the researcher. This was certainly not the case at this institution. MRC is an excellent example of a Council on Undergraduate Research institution that has overcome many of the negative stereotypes associated with IRBs. From a public policy theory standpoint, they have implemented federal human subject research public policy in a way that is institution-specific and student- and faculty-friendly. This College is an excellent example of what a "best practices" undergraduate research college is all about.

Author's Note

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Kristi N. Hottenstein, Ph.D.
Vice Chancellor for Enrollment Management
University of Michigan-Flint
3032 E. Kearsley St.
Flint, MI 48502
Tel: (810) 762-5723
Email: khottens@umflint.edu

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Reducing the Time for IRB Reviews: A Case Study

Andrea Pescina Liberale
University of Houston

Jamison V. Kovach
University of Houston

Abstract: *Research activities often involve enrolling human subjects as volunteers to participate in research studies. Federal regulations mandate that research institutions are responsible for protecting the ethical rights and welfare of human subjects from research risks. This is usually accomplished by requiring approval of research protocols by an institutional review board (IRB) through a review process that is often complicated and time-consuming. The aim of this research was to reduce the time to obtain IRB approval/denial decisions for research protocols. Through a case study, this research addressed this issue within a leading public research university using the Lean Six Sigma methodology, a structured, problem-solving approach for improving process performance. Analyzing the IRB review process and implementing solutions to address the root cause(s) of lengthy processing times helped to streamline this process, which enhanced investigators' ability to conduct their research in a timely manner, while also ensuring compliance with federal regulations for human subject research.*

Keywords: *Research administration, Institutional review board (IRB) approval/denial process, Lean Six Sigma, process improvement efforts*

Introduction

Research activities, such as clinical trials for example, involve enrolling human subjects as volunteers to participate in research studies (Gabriele, 2000). Given that a substantial portion of research is sponsored by the federal government through money collected from U.S. taxpayers, investigators and research institutions have a responsibility to ensure research funding is not used in ways that harm or unnecessarily risk harming subjects participating in research studies. Given the volume of regulations, guidelines, etc. regarding research involving human subjects at the federal, state, and local levels, however, it can often be challenging to maintain compliance (Steinert, 2002). This research investigates how to reduce the time to review and render approval/denial decisions for research protocols that involve human subjects.

To ensure the ethical conduct of research involving human subjects, institutions that receive federal funding for research are required to establish an institutional review board (IRB). The intent of the IRB is to protect the ethical rights and welfare of human subjects from research risks through the initial and continuing review of research protocols, adverse events, amendments, and other issues. The policies and procedures used to guide this process within each institution assists investigators with maintaining compliance with federal regulations (Steinert, 2002). That is, the modifications to research protocols, consent forms, recruitment materials, etc. often requested

by IRB committees are meant to balance the risks and benefits of a proposed research protocol (Gabriele, 2003; Gearhart, 2010).

Due to the competitiveness of research environments, it is imperative that institutions continuously improve their administrative support processes in order to help investigators effectively fulfill the requirements associated with their research activities (Kakande & Namirembe, 2012). One reason for investigator dissatisfaction is often the long wait times associated with obtaining IRB approval/denial decisions for research protocols (Whitney et al., 2008). Following an action research approach (Reason & Bradbury, 2008), researchers worked closely with IRB program administrators at one leading public research university to reduce the time to obtain IRB approval/denial decisions. Through a case study, this research demonstrates how this issue was addressed using the Lean Six Sigma methodology, which is a structured, problem-solving approach to improve process performance that combines Lean and Six Sigma tools to increase quality and reduce waste (Pepper & Spedding, 2010). Improving the efficiency of this process helps investigators conduct their research in a timelier manner, while also ensuring compliance.

The following sections provide details on the background, methodology, and the case study with results and conclusions. In the background section, information is provided regarding the IRB review process and some methods others have used previously to improve this process. The methodology section discusses the approach used to guide this research. This is followed by the case study section, which provides a detailed description of the work performed to improve the IRB review process. It also includes a description of the institution in which this research was conducted, as well as a discussion regarding how each phase of the Lean Six Sigma methodology was applied. Finally, the results of this improvement effort are summarized along with some concluding remarks regarding the implications of this research and areas for future work.

Background

Protocols for research involving human subjects typically fall into one of three review categories: 1) exempt (i.e., studies involving collecting new or existing data in such a manner that subjects cannot be identified, which are reviewed only by IRB program administrators); 2) expedited (i.e., studies posing minimal risks to human subjects, such as the collection of biological specimens via noninvasive means, which are reviewed by only one IRB committee member); or 3) full review (i.e., studies involving a larger range/higher level of potential risks to human subjects that do not qualify as exempt or expedited, which are reviewed by a full IRB committee) (Steinert, 2002). A recent study by the Association for the Accreditation of Human Research Protection Programs (AAHRPP, 2015) found that in the U.S. research protocols requiring full review take the longest amount of time (i.e., the median time from submission to an approval/denial decision is 39 days).

Many factors play a role in determining how long it takes to obtain IRB approval/denial decisions for a research protocol. There is a large body of regulatory requirements that must be referenced during research protocol reviews. Protocols must also be reviewed prior to the initiation of research activities and annually thereafter for on-going protocols (Gabriele, 2000). In addition, IRB program administrators and/or committee members often have heavy workloads. For example, nearly 40 percent of research intuitions have only one IRB committee, and a median

of 471 protocols require full review by each institution annually in the U.S. (AAHRPP, 2015). Given this workload, there can often be insufficient time for IRB program administrators and/or committee members to meticulously review protocols (Gabriele, 2000). Furthermore, IRB committee meetings often tend to be time consuming, and/or it can be difficult to obtain a quorum. Both of these issues contribute to long wait times for consideration of new protocols or reconsideration of revised protocols.

Investigators also contribute to the length of time needed for the IRB review process by not always providing sufficient information in their research protocols so they can be adequately reviewed. This situation, unfortunately, often leads to multiple cycles of revisions and re-reviews (Blustein, Regenstein, Siegel, & Billings, 2007; Green, Lowery, Kowalski, & Wyszewianski, 2006; Shalala, 2000). This situation is often further exacerbated when institutions' IRB program administrators have insufficient resources and/or poorly organize/use available resources to support the review process (Andrews, Moore, Mean, & Weinberg, 2012).

Suggestions for reducing the time to obtain IRB approval/denial decisions include encouraging investigators to start working on their IRB applications as early as possible. Also, they can schedule meetings with IRB committee members to obtain guidance regarding potential risks and how to address them in advance of submitting their research protocol for review. Providing templates that address typical issues covered in IRB applications, including research questions, study design, sampling approach, recruitment procedures, and consent processes/forms, that investigators can tailor to meet their needs have been used previously to streamline the review process (Blustein et al., 2007). Finally, to avoid imposing requirements that are not appropriate for the proposed research, which unnecessarily extends the revision and re-review process, systems are needed to ensure IRB committee members have the correct experience and understanding to conduct reviews for their assigned protocols (Green et al., 2006).

To improve the IRB review process, one research institution recently developed metrics within a structure-process-outcome model to systematically analyze various aspects of their process for efficiency and determine the ethical issues that tend to prolong the review process (Adams et al., 2014). Another institution addressed this problem by reducing the size of each IRB committee, doubling their total number of committees, increasing the frequency of committee meetings, but scheduling meetings for shorter periods of time. This approach not only reduced the time to obtain IRB approval/denial decisions by nearly 50 percent, but it also increased the quality of reviews because more frequent meetings with shorter agendas allowed committee members to more carefully review each protocol (Andrews et al., 2012).

Research Context

This research was conducted at the University of Houston, which has approximately $100 million in research expenditures annually. In accordance with federal regulations, the University has an IRB review process that is managed by staff in the Division of Research's Office of Research Policies, Compliance, and Committees. Faculty, staff, and students proposing to engage in any research activity involving the use of human subjects must obtain IRB approval prior to the recruitment for and initiation of research procedures. To handle the large volume of research

protocols that require full review, the University of Houston has established three separate IRB committees. Each committee follows the same review process, and individual research protocols are reviewed by one of these three committees depending on the college from which the protocol was submitted. Each IRB committee has approximately 10 members with at least five alternate members. Members of these committees include representatives from the colleges and departments that submit to the committee, members not affiliated with the University of Houston, graduate students, a prisoner representative, and administrators that work in the Division of Research.

Unfortunately, the IRB review process for research protocols that require full review at the University of Houston has a median value of over 50 days. This is more than 10 percent longer than the median time in the U.S. to render an IRB approval/denial decision. In order to better serve those conducting research involving human subjects and increase their capacity to support research activities, the Division of Research undertook a Lean Six Sigma project to reduce the time to obtain IRB approval/denial decisions.

Methodology

This research applied the Lean Six Sigma methodology to reduce the time to obtain IRB approval/denial decisions for a research protocol through a case study. The aim of Lean and Six Sigma are to reduce waste and variation within operational processes (Schroeder, Linderman, Liedtke, & Choo, 2008; Shah & Ward, 2007). Six Sigma alone was originally developed as a structured problem solving approach for use in production environments (Pande, Neumann, & Cavanagh, 2000). More recently, however, Lean and Six Sigma approaches have evolved into a combined methodology for improving process efficiency and reducing defects/errors/mistakes (Pepper & Spedding, 2010). The combined approach, Lean Six Sigma, has been used successfully to improve process performance in a variety of industries including services operations such as financial services (de Mast, Kemper, Wiltjer, & Does, 2013), construction (Anderson & Kovach, 2014), and education (Kulkarni & Kovach, 2016).

Process improvement projects using the Lean Six Sigma methodology follow a structured approach that has five phases: Define, Measure, Analyze, Improve, and Control (DMAIC). In the Define phase, the problem/opportunity for improvement and the key stakeholders are identified. At this point, a project team is also established, and management approval for the project is obtained. The Measure phase includes mapping the process, analyzing the measurement system, and establishing a baseline measurement regarding the current process performance. During the Analyze phase, the project team identifies the potential causes of the problem and evaluates them using process and/or statistical analysis methods to determine the vital few root cause(s). The Improve phase consists of identifying potential solution(s) to address the root cause(s) identified previously, narrowing them down to the sub-set of solutions that best addresses the problem at hand, and fully implementing the selected solution(s). Finally, the Control phase involves establishing a control plan to ensure that the changes implemented regarding how work is to be performed will be sustained and the performance gains made through the project will not be lost over time (de Mast & Lokkerbol, 2012; Hahn, Doganaksoy, & Hoerl, 2000).

Using this methodology, the University of Houston's Division of Research engaged in a

participatory action research method of inquiry that involved staff and researchers working together. The aim of action research is to develop practical solutions to a pressing problem through the integration of action and reflection (Reason & Bradbury, 2008). Using this type of approach provided an opportunity for researchers to function as participants in the University's Lean Six Sigma project through meetings and office visits; hence, researchers, along with staff at the University, were involved in analyzing the IRB review process to identify cause(s) of waste and together implemented changes to reduce the time to obtain approval/denial decisions for a research protocol. Within this framework, the action research process of planning, taking action, and evaluating the action, which leads to planning for further action was used to ensure that what was learned from one phase of the project was then used as the input to the subsequent phase (Coughlan & Coghlan, 2002).

In the end, the Division of Research felt that the improvements made to streamlining their IRB review process would provide them with additional capacity to support research activities without having to hire additional staff; hence, the main question guiding this research was how does the University need to change their IRB process to effectively reduce the time to review a research protocol? The next section provides a detailed account the work done in each phase of the DMAIC methodology to develop a practical solution to the problem of long wait times for investigators to obtain IRB approval/denial decisions for their research protocols.

Case Study

Define Phase

The team involved in this project included staff working in the IRB review process, and it was led by the Assistant Director of the Office of Research Policies, Compliance, and Committees. Together, this team developed a project charter that identified the need for the project, as well as the responsibilities of the team members involved. To describe the situation at the beginning of the project and the project's specific objectives, the following problem and mission statements were developed:

> *Problem statement*: The University of Houston's process to obtain IRB approval/denial decisions for research protocols that require a full committee review has averaged 52.27 days over the last six months (July–December 2015), resulting in delays and/or cancellations of research activities/studies.
>
> *Mission statement*: Reduce the average time to obtain IRB approval/denial decisions for research protocols that require a full committee review to 46 days or less (a 15 percent reduction) over the next nine months (by September 2016), resulting in fewer delays and/or cancellations of research activities/studies.

Measure Phase

In this phase of the project, the team outlined the IRB review process using a suppliers, inputs,

process, outputs, and customers (SIPOC) diagram, as shown in Figure 1. The center column of Figure 1 describes the general steps required to approve a research protocol that requires a full IRB committee review. First, the Division of Research's Office of Research Policies, Compliance, and Committees receives a protocol, and a pre-review is conducted to confirm 1) the review category specified is correct, 2) all required documents were submitted, and 3) the required training has been completed by the investigator. Then, the research protocol is assigned to an IRB committee, and the primary and secondary reviewers (i.e., IRB committee members) are assigned. Once the reviews are complete, the IRB committee meets to analyze the protocol and its review, and they render a decision. Then, the decision is sent to the investigator. If modifications were requested, the investigator revises and resubmits the research protocol, which is reviewed again. Finally, the revised protocol and its review are analyzed in an additional IRB committee meeting, and if no further modifications are needed, the committee renders a final decision. If approved, the investigator can then begin their research activities following the approved protocol.

Suppliers	Inputs	Process	Outputs	Customers
Investigators Division of Research – Office of Research Policies, Compliance, and Committees Federal government	Research protocol Reviewers (faculty, staff, etc.) Online submission system Research regulations	1. Receive research protocol 2. Assign to IRB committee 3. Assign primary and secondary reviewers 4. Review research protocol 5. Analyze protocol and its review in IRB meeting 6. Render decision 7. Send decision to investigator 8. Modify protocol, if needed 9. Repeat steps 4-8, as needed	Modifications Approved/ denied protocol	Investigators Research participants Division of Research – Office of Research Policies, Compliance, and Committees

Figure 1. High-level view of the IRB review process.

As additionally shown in Figure 1, the inputs for the IRB review process are the research protocol, reviewers (i.e., faculty, staff, etc.), online submission system, and research regulations, which are supplied by researchers, the Division of Research's Office of Research Policies, Compliance, and Committees, and the federal government. The outputs of this process are protocol modifications and the approved/denied protocol. These outputs are used by researchers, research participants, and the Division of Research's Office of Research Policies, Compliance, and Committees. To ensure the project team had a detailed understanding regarding how the process operates, a process map illustrating the step-by-step nature of the IRB review process was also created, which was three pages long (not included due to space limitations).

To measure the current performance of the IRB process regarding the time to obtain an approval/denial decision for a research protocol that requires a full committee review, date stamp data for protocols processed July through December 2015 were collected from the University's research administration database. During this time, nearly 70 research protocols that required a full IRB committee review were processed. The process cycle time was calculated by subtracting the date a research protocol was submitted from the date the protocol approval/denial decision was sent to the investigator. The time to obtain IRB approval/denial decisions for protocols that required a

full committee review varied from 11 days to 127 days with an average of 52.27 days and a standard deviation of 33.23 days. Instances where it took approximately 100 days or more to obtain IRB approval/denial decisions occurred for approximately 15 percent of the research protocols reviewed.

Analyze Phase

To identify the root cause(s) of excessive time to obtain IRB approval/denial decisions for a research protocol that requires a full committee review, the project team utilized failure modes and effects analysis (FMEA) to analyze the process. FMEA is an analytical tool that identifies and prioritizes potential failures in a process (Stamatis, 2003). Using this tool, the team determined how each step in the process could fail, the effect(s) and cause(s) of the failure, and the current control(s) in the process that may help detect/prevent the failure. The project team also utilized a 10-point rating scale to evaluate each failure according to 1) the severity of the effect, where "10" represents a catastrophic event and "1" represents an issue that is not noticeable to the customer; 2) the occurrence of the potential cause, where "10" represents the cause is almost certain to occur and "1" represents it is highly unlikely the cause will occur; and 3) the current control's ability to detect/prevent the failure, where "10" represents the control is nearly certain not to detect the failure/no controls and "1" represents the control is almost certain to detect the failure.

Once all aspects of the IRB review process had been evaluated, the failures identified were prioritized based on their risk priority number (RPN), which is calculated by multiplying the ratings for severity, occurrence, and detection, in order to determine which items in the process represent the highest risk of failure. The items with the highest RPNs are shown in Table 1. These items represent the failures with highest risk of causing delays within the IRB review process. The causes associated with these failures include 1) missing coversheet and 2) not enough time for Coordinators, i.e., IRB process administrators, to conduct the protocol pre-review. Based on the RPN values, the project team identified these two items as the root causes for excessive time to obtain IRB approval/denial decisions.

Table 1. Top-rated Failures Associated with IRB Review Process Delays

Process Step	Potential Failure Mode	Potential Effect of Failure	Severity	Potential Cause	Occurrence	Control	Detection	RPN
Reviewers review the re-submitted protocol	Coordinator does not understand how the protocol was revised to address required changes	Takes more time to complete review	10	Missing coversheet explaining how protocol was revised	10	None	10	1000
Coordinator checks revisions to the protocol		PI needs to be contacted to explain changes	10		10	None	10	1000
Required revisions made in the protocol?			10		10	None	10	1000
Coordinators pre-review the protocol	The protocol is not pre-reviewed correctly	Protocol goes to the IRB committee meeting with missing documents/ information	7	Not enough time to conduct the protocol pre-review	9	None	10	630

Improve Phase

After determining the root causes, the project team began to compile a list of potential solutions to address each of these issues. When considering root cause 1 (missing coversheet), one idea the project team identified was to eliminate the need for a coversheet explaining how the research protocol had been revised. As the team investigated how this could be accomplished, they learned that the University was in the process of implementing a new online system for managing the IRB review process. When the project team inquired about the operations of this new system, they learned that it had the capability to show the original research protocol compared with the revised version in a split screen. This optional function in this new system would make it easy for Coordinators to understand how the protocol was revised to address requested modifications during their pre-review. To eliminate the need for a coversheet to be submitted with revised research protocols, the project team recommended this function be enabled in the new online system.

For root cause 2 (not enough time for Coordinators to conduct the protocol pre-review), the project team held a brainstorming session. Each team member individually prepared a list of potential solution ideas. During the brainstorming session these ideas were shared and other ideas were developed by the team. In the end, the project team identified six ideas to address the need for creating more time for Coordinators to conduct protocol pre-reviews. Nominal group technique was then used to prioritize this list of solution ideas. That is, once project team members had individually rank-ordered the ideas developed, this information was compiled, the sum of individual rankings for each solution idea were calculated, and the ideas were prioritized based on their total score from highest to lowest, as shown in Table 2. The solution with the

highest total score was "delegate Coordinator's other responsibilities to student workers" (i.e., lower-skilled tasks) so Coordinators would have more time to conduct protocol pre-reviews (i.e., a high-skilled task).

Table 2. Prioritized Potential Solutions for Root Cause 2 – Not Enough Time to Conduct the Protocol Pre-review

Potential Solution Idea	Team Member				
	A	B	C	D	Total
Delegate Coordinator's other responsibilities to student workers	6	6	6	6	24
Do not accept revised protocol submissions after a certain time in advance of an IRB committee meeting	5	3	5	5	18
Establish specific days to conduct protocol pre-reviews	4	2	3	4	13
Move-up the deadline for finishing protocol pre-reviews in advance of an IRB committee meeting	2	5	4	2	13
Schedule protocols without pre-reviews completed for an alternate IRB committee meeting at a later date	3	4	2	3	12
Change the date of the IRB committee meeting when protocol pre-reviews are not complete	1	1	1	1	4

In order to delegate some of the Coordinator's time consuming, lower-skilled tasks to others involved in the IRB process, a brainstorming session was held to identify which activities could be completed by student workers. The tasks identified included 1) using checklists to ensure required documents and training have been submitted/completed for each research protocol; 2) sending letters, i.e., protocol approvals, closures, and confirmations for non-human subjects research; 3) filing approval memos; and 4) managing the IRB process' common e-mail inbox. In order to ensure everyone involved would understand the new way of performing this work, a description for each of these new tasks was developed and the people responsible for each of these tasks were identified. Over the next week, Coordinators trained student workers on how to perform these activities.

Control Phase

In order to sustain the improvements made to the IRB process as a result of this project, a control plan was established that included documenting, training, auditing, and monitoring mechanisms for the improved process. As previously discussed, the work activities delegated to student workers were documented and the student workers were trained by the Coordinators regarding how to perform these tasks. An overview of the audit and monitoring aspects of the control plan are shown in Table 3. The items listed provide a structure for process monitoring that specifies the steps, or work, in the IRB review process to be performed along with the control methods, their frequency, and the owners, i.e., those responsible for overseeing each control mechanism. Similarly, the last few columns of Table 3 specify the methods to audit the process control mechanisms, their frequency, and the assigned owner, as well as the person to which the audit results are to be reported.

As shown in Table 3, for example, the process step "conduct protocol pre-review" will be controlled by checking that all pre-reviews are complete a week before the IRB committee meeting, and this will be done bi-weekly by the Coordinators. In addition, this control activity will be audited by

reviewing the protocol pre-review report, which will be done bi-weekly by the Assistant Director of the Office of Research Policies, Compliance, and Committees, and the audit results will be reported to the Director. Finally, it was determined that a run chart, similar to that depicted in Figure 2 (shown in the next section), would be used to monitor the performance of the improved process relative to the time to obtain an IRB approval/denial decisions for a research protocol.

Table 3. Control Plan for Auditing and Monitoring the Improved IRB Review Process.

Process Step	Control Method (frequency)	Control Owner	Audit Method (frequency)	Audit Owner	Report Audit Results To
Conduct protocol pre-review	Check all pre-reviews are completed a week before the IRB committee meeting (bi-weekly)	Coordinators	Review protocol pre-review report (bi-weekly)	Assistant Director	Director
Notify investigator regarding missing documents	Check that emails sent to investigators are filed in shared folder (immediately after sending)				
Receive missing documents	Check that missing documents are received by the Friday before the IRB committee meeting (bi-weekly)				
Manage the IRB process' common email in-box	Check that all emails have been moved forwarded to the correct person/moved to the appropriate folder (weekly)	Student workers	Review email management and discuss feedback in team meetings with student workers (monthly)	Coordinators	Assistant Director

Results

After the new online system had been implemented and students working in the IRB process had been completing the new tasks delegated to them on their own for approximately three months, data were collected from the University's research administration database to determine the performance of the improved IRB review process. Figure 2 depicts a run chart of the time to obtain IRB approval/denial decisions, i.e., the date a protocol approval/denial decision was sent to the investigator minus the date the research protocol was submitted, for July 2015–September 2016. During this time, more than 120 research protocols that required a full IRB committee review were processed. The data shown in Figure 2 from July–December 2015 represents the baseline measurement for this project, which was discussed previously in the Measure phase. The data shown from January–May 2016 depicts the performance of the IRB review process while the project team conducted their investigation of the process to identify the root causes and develop solution ideas. Finally, the data shown from June–September 2016 represents the performance of the improved IRB review process after the solutions identified through this project were implemented. As a result of this project, the time to obtain IRB approval was reduced from an average of 52.27 days with a standard deviation of 33.23 days at the beginning of the project (July–December 2015) to an average of 46.96 days with a standard deviation of 20 days by the end of

the project (June–September 2016). These data provide initial evidence that the improvements implemented through this project were effective in terms of reducing the time to obtain an IRB approval/denial decision.

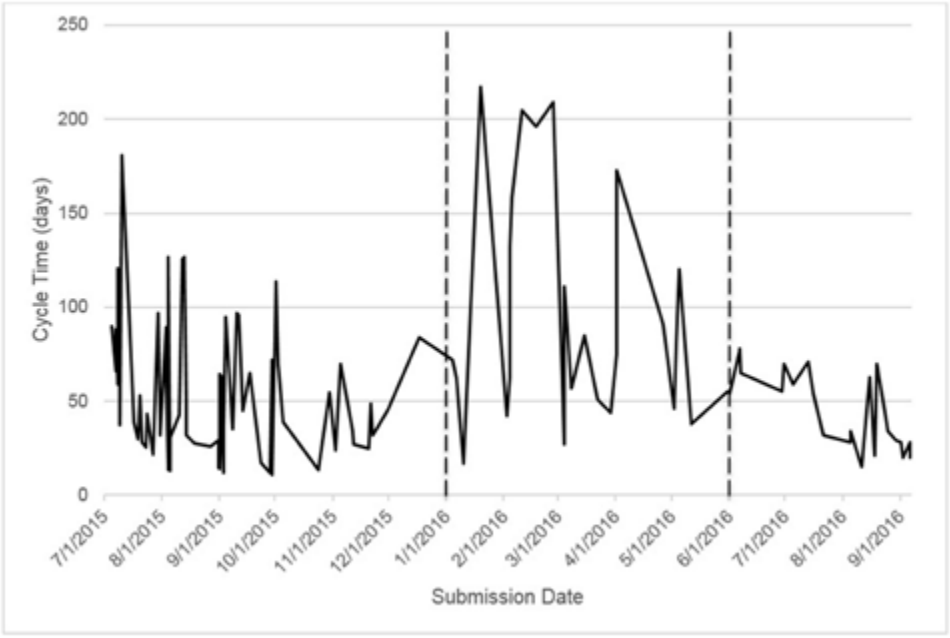

Figure 2. Performance of the IRB review process over time.

Conclusion

Through a case study at one institution, this research demonstrated how to apply the Lean Six Sigma methodology to improve the IRB review process. This study successfully identified what the university in which this research was conducted needed to do to reduce the time to obtain IRB approval/denial decisions for research protocols that require full review. Through this research, the time to obtain IRB approval/denial decisions was reduced by approximately 15 percent. This was achieved through two actions. First, the project team recommended enabling a feature within the new online system for managing the IRB process to make it easier for Coordinators to check the revisions made to research protocols in response to requested modifications during their pre-review. Without this specific recommendation, it is not clear whether the other group responsible for implementing the new system would have recognized the importance of and enabled this particular system feature on their own. Second, the project team helped Coordinators delegate some of their time consuming, lower-skilled tasks to student workers to create more time for Coordinators to conduct protocol pre-reviews.

Because this research describes a case study performed in just one research institution, the results obtained may not be generalizable to all IRB review processes. However, the approach may be useful to other IRB program administrators and/or committee members to provide guidance for

conducting similar process improvement efforts within their institutions in the future. Finally, given that the case study conducted in this research focused on research protocols that require full IRB committee review, the next step for the university that participated in this research is to use the principles and practices of Lean Six Sigma to further improve their IRB review processes for research protocols that require exempt and/or expedited reviews.

Authors' Note

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Andrea Pescina Liberale
Master's Candidate
University of Houston
4730 Calhoun Rd. Room 300
Houston, Texas 77204, U.S.A.
Phone: 713-743-1704
Fax: 713-743-4032
Email: aapescinaliberale@uh.edu

Jamison V. Kovach
Associate Professor
University of Houston
4730 Calhoun Rd. Room 300
Houston, Texas 77204, U.S.A.
Phone: 713-743-1704
Fax: 713-743-4032
Email: jvkovach@uh.edu

Correspondence regarding this article should be addressed to Jamison V. Kovach, Associate Professor, University of Houston, 4730 Calhoun Rd. Room 300, Houston, Texas 77204, U.S.A., jvkovach@uh.edu

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Organizational Cultural Theory and Research Administration Knowledge Management

Dwayne W. Lehman
Carnegie Mellon University

Abstract: *The administration and management of sponsored projects spans many levels within an institution of higher education. Research administration professionals require an operational understanding of a complex and intertwined set of disciplines that include project management, finance, legal, ethics, communication, and business acumen. The explicit knowledge needed for research administration is visible in work processes, policies, procedures and organized knowledge repositories. The implicit, or tacit knowledge required for the profession is much more difficult to externalize, codify, store and share. The management of this knowledge is greatly affected by the culture of the organization where the person works and the research administration community of practice. By applying organizational culture theory to the research administration profession and exploring shared artifacts, espoused beliefs and values, and basic underlying assumptions, barriers and opportunities for knowledge management initiatives are realized. Creating and sustaining a knowledge-sharing community involves establishing knowledge leaders in organizations that exhibit the ideals, beliefs and principles of the profession, allocating opportunities for research administration professionals to communicate and share, utilizing dynamic information systems, and establishing metrics for knowledge management initiatives.*

Keywords: *research administration, knowledge management, organizational culture theory, higher education*

Background and Objectives

Research conducted at colleges and universities is big business. It is an integral part of a institution's mission and represents a significant portion of the academic activity on campuses. The research endeavors can increase the prestige and competitive standing of the institution (Turk-Bicakci & Brint, 2005). In response to this climate, higher education institutional leaders are promoting and developing more complex research strategies that include interdisciplinary, intercollegiate, and international collaborations (Derrick & Nickson, 2014; Langley & Huff Ofosu, 2007; Rutherford & Langley, 2007; Turk-Bicakci & Brint, 2005). As the political and global environment of sponsored research at universities increase, so do the management, fiscal accountability, and reporting requirements of research projects (Lintz, 2008; Rutherford & Langley, 2007; Smith, Trapani, Decrappeo, & Kennedy, 2011). These factors have expanded the administrative requirements of research and increased the essential domain of knowledge that research administrators must possess to accomplish their responsibilities.

The administration and management of research at an institution of higher education is a multifaceted task that spans an institution. Collectively research administrators at institutions of higher education form a *community of practice*. A community of practice is defined as a group of people, who share a craft or profession (Lave & Wenger, 1991). Research administration across institutions of higher education also forms a type of organization. March and Simon (1993) define an organization as a "system of coordinated action among individuals or groups whose preferences, information, interests, or knowledge differ" (Organizations, p. 2). An organization survives through the control of information, formation of an identity, creation of shared stories and incentivizing acceptable behaviors (March & Simon, 1993).

Research administration represents the business support necessary for the success of any exploratory initiative (Kulakowski & Chronister, 2006). The collection of knowledge that research administrators are required to grasp in order to accomplish their duties spans a diverse range of disciplines. These professionals require a working knowledge of business and project management, and the legal, ethical, scientific, and fiscal components of academic research (Kulakowski & Chronister, 2006; Shambrook & Roberts, 2011). In order for the profession to grow and evolve, this knowledge has to be collected, categorized, and shared among the research administration community of practice. The successful management of knowledge in any organization is highly influenced by culture. Applying organizational culture theory to the research administration profession and exploring the shared artifacts, espoused beliefs, values, and basic underlying assumptions of research administration, reveals common barriers to knowledge management and opportunities for creating a knowledge-sharing research administration community of practice.

Knowledge and knowledge management

Knowledge is the most valuable resource in any organization. It is the cornerstone of an institution's competitive strategy and necessary for an organization's survival (Davenport & Prusak, 1998; Naserieh, Pourkiani, Ziaadini, & Fahim, 2012; Serban & Luan, 2002; Schmitz, Rebelo, Gracia, & Tomas, 2014). Knowledge enables a person to interpret incoming information and data about a situation and identify the implications of that information to either take action or ignore it (Steyn, 2004). Davenport and Prusak (1998) provide a comprehensive definition of knowledge:

> Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms. (p. 5)

Knowledge differs from data or information. Data is a collection of separate, objective facts about an event that can be measured qualitatively or quantitatively, but provides no interpretation, or basis for action (Davenport & Prusak, 1998; Serban & Luan, 2002). Information is data that has been given shape and organized in some manner by the members of an organization to be relevant and purposeful (Davenport & Prusak, 1998; Drucker, 1988, O'Dell & Grayson, 1998). Knowledge therefore, "is the application of experience and judgement to information by an individual, group or organziation" (Serban & Luan, 2002, p. 8). Knowledge results when people

personally transform information into their personal knowledge, store it, and use it to create new knowledge.

Knowledge can be characterized as having two forms: explicit and tacit. Explicit and tacit knowledge are not mutually exclusive, but coexist within an institution at the individual, group, and organizational levels (O'Dell & Grayson, 1998; Sabherwal & Becerra-Fernandez, 2003; Serban & Luan, 2002). Explicit knowledge is found in an organization's policies, procedure manuals, and institutional documents such as the mission, vision and value statements and is easily codified, stored and transferred (Gao, Meng, & Clarke, 2008; Kidwell, Vander-Linde, & Johnson, 2000). Tacit knowledge is personal and individualized. It is created and validated by personal experience, contextualized in specific situations, influenced by personal values, and cannot be easily communicated or transferred (Cardoso, Meireles, & Ferreira Peralta, 2012; Kidwell et al., 2000; Nonaka, 1994; Polanyi 1966). It is the management of this knowledge, specifically tacit knowledge, that promises to deliver huge returns for organizations and occupations that learn use it effectively (Kidwell et al., 2000).

Management of this knowledge is critical to the success of the profession of research administration and the institutions in which research administrators work. Knowledge management in higher education can lead to better decision-making capabilities, reduce costs, and improve the efficiency and effectiveness of academic and administrative services by transforming tacit knowledge into explicit knowledge (Kidwell et al., 2000; Steyn, 2004). Knowledge management can be defined as the systematic process of identifying, capturing, and transferring the know-how, experience, and intellectual capital of people within organizations (Davenport & Prusak, 1998; Nonaka, 1994; Steyn, 2004). There are six phases in the knowledge management process according to Cardoso (as cited in Schmitz et al., 2014): creation and acquisition; attribution of meaning; sharing and diffusion; organization memory; measurement; and recovering. "The success of a knowledge management program is measured using the dimensions of the impact on business processes, strategy, leadership, organizational culture, and the efficiency and effectiveness of knowledge management processes" (Jennex, Smolnik, & Croasdell, 2009, p. 183).

A key component of knowledge management is to create new knowledge within an organization, thus promoting its continued existence and value to stakeholders (Nonaka, 1994). The same is true for the profession of research administration. Knowledge management initiatives are accomplished by making intellectual capital available to others (Nonaka, 1994; Steyn, 2004). Knowledge creation is accomplished through four modes as described by Nonaka (1994): socialization, externalization, internalization, and combination. "New knowledge starts with individuals sharing their internal tacit knowledge through socializing with other people or by obtaining it in digital or analog form" (Steyn, 2004, p. 618). Culture plays a vital role in the accomplishment of knowledge management.

Organizational culture

Culture is an important aspect of any institution and yet, it is difficult to find a single, unified definition of culture. Shein (2010) defines organizational culture as "A pattern of shared basic assumptions learned by a group as it solved its problems through external adaption and internal

integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems" (p. 18). An organization's culture can be divided into three levels: *artifacts, espoused beliefs and values, and basic underlying assumptions* (Schein, 2010). Artifacts are easily observed in the physical spaces of the institution, the apparent behaviors of employees, and how work is organized and processed (McDermott & O'Dell, 2001; Schein, 2010). *Artifacts* can be aligned with the explicit knowledge within an organization. *Espoused beliefs and values* can be seen in the organization's stated vision, mission and goals but also can be found in individual ideals, principles and personal aspirations (McDermott & O'Dell, 2001; Schein, 2010). This level of culture is expressed as explicit knowledge and also the more personal, unspoken tacit knowledge. The cultural level of *basic underlying assumptions* represents the unstated thoughts, feelings, and perceptions that influence decision-making actions and employee behavior (Schein, 2010). This deeper level of culture is the invisible dimension of an organization not easily or readily communicated and relates to tacit knowledge (McDermott & O'Dell, 2001). In addition to these levels of culture within an institution, there also exist a collection of subcultures and micro-cultures that are based on organizational hierarchy, geographic location, or are defined by a common set of functions or tasks performed by a group of individuals (Schein, 2010). Each of these subcultures and micro-cultures can have their own artifacts, espoused beliefs and underlying assumptions within the same institution. Issues within organizational culture present some of the most difficult barriers to knowledge management success (Conley & Zheng, 2009) because it determines what 'knowledge' is, how it is stored and communicated, and what knowledge is important.

Organizational culture and the impacts on knowledge management

An institution's culture significantly impacts knowledge and knowledge management (KM) tools, processes, and initiatives (McDermott & O'Dell, 2001). Leibowitz (1999) states that knowledge management is 90% dependent on building a supportive KM culture. Furthermore, Wong and Aspinwall (2004) indicate that culture is the second most critical success factor to KM behind leadership/management support. There are four primary ways in which the culture of an institution and knowledge management interact within an organization., Institutional culture: 1) shapes assumptions and determines what knowledge is useful and important to an organization; 2) empowers those who owns a particular knowledge; 3) determines what is the knowledge; and how is it communicated; and 4) decides the acceptance or rejection of new knowledge through validation by the organization (DeLong, 1997). These intersections influence the success or failure of KM projects.

Four barriers exist to the successful sharing and transferring of knowledge within an organization that are directly related to an institution's culture. The first barrier is ignorance on both ends of the transfer of knowledge (Serban & Luan, 2002; Szulanski, 1993), i.e., individuals with knowledge do not realize its value to others, and others seeking knowledge do not know where to find it. The second barrier is the lack of resources to obtain the knowledge (O'Dell & Grayson, 1998; Szulanski, 1993). This barrier reflects the lack of internal processes or technology to enable the collection, retrieval, and sharing of knowledge. The third barrier is the lack of relationship between a knowledge holder and the knowledge receiver (Serban & Luan, 2002; Szulanski, 1993);

opportunities for the social exchange of information through shared experiences and storytelling are hindered by the organization's structure and the value of collaborative spirit. Lastly, the slow rate of adoption of new knowledge is caused by a lack of motivation within the organization which creates a barrier to KM and is impacted by the organization's reward system (Davenport & Prusak, 1998; O'Dell & Grayson, 1998; Szulanski, 1993).

Higher education institutions are often structured by function or discipline that operate independently of each other and with varying degrees of autonomy. Higher education institutions are also bureaucratic entities with complex political systems that serve different interests of stakeholders (Ramachandran, Chong, & Ismail, 2009). Inherently, "as in the business environment, functional areas within many higher education institutions often fail to share knowledge that can lead it to the establishment of a higher standard of education" (Ramachandran, et al., 2009, p. 204). Adding complexity to this environment is the dual challenge research administrators face: simultaneously serving the researcher, while promoting and protecting the best interest of the organization (Lankford, 1997). These barriers must be successfully addressed to promote a learning organization.

Methods

The supporting data presented in this paper are the results of the first round of a Delphi study, which was part of a larger exploratory sequential mixed-methods research project.

Delphi technique

The Delphi method leverages the knowledge and experiences of a select group of experts or qualified professionals to obtain a consensus on multidimensional issues or topics. This methodology is appropriate for researching complex issues such as those found in the profession of research administration "where large scale quantitative hard data fails to unearth the richness in tacit knowledge to help the research understand subtle expert opinion" (Grisham, 2009, p. 112). There are four goals associated with a Delphi study: 1) gather and summarize knowledge from an expert panel; 2) obtain an agreement or consensus concerning the topic or issue; 3) explore ideas with knowledgeable participants; and 4) provide information to aid in decision-making (Abu, Ritchie, & Jones, 2012). The Delphi technique was developed by the RAND Corporation in the late 1950's as a method to aid in policy creation and decision-making (Dalkey, 1967).

The Delphi research method has several additional advantages. The first is participant anonymity (Dalkey, 1967); participants individually provide their responses to prepared questions directly to the researcher thus reducing group pressure and the influence of dominant individuals (Dalkey & Helmer, 1963; Grisham, 2009). The second benefit is that through a repetitive, or iterative process it forms a consensus among the expert panel (Dalkey, 1967; Abu et al., 2012). Thirdly, the Delphi Method is systematic, flexible, and allows for the use of a variety of communication methods and tools (Dalkey, 1967; Abu et al., 2012). Lastly, it produces reliable and valid results (Abu et al., 2012; Dalkey, 1967; Grisham, 2009). Grisham (2009) states that, "The Delphi technique has been demonstrated in the literature as a reliable empirical method for consensus

reaching" (The Delphi technique: a method for testing complex and multifaceted topics , p. 116).

Population and sample

A purposive sampling technique was employed for this study. Bryman (2012) states, "The goal of purposive sampling is to sample participants in a strategic way so that those sampled are relevant to the research questions that are being posed" (p. 418). A study utilizing the Delphi technique can have any number of participants. The ideal sample size of experts is one that is large enough to represent the population, conduct the desired research, and yet is manageable by the researcher (O'Leary, 2014).

The population for this study consists of self-identified research administrators from Very High and High Research Institutions according to the Carnegie Classification of Institutions of Higher Education. The minimum requirements for the participants were at least eight years in the field of research administration, familiarity with both the pre-award and post-award research activities, and routine use of an institutional information system to manage sponsored research. The recruitment of participants was conducted through e-mail solicitations. Confidentiality of the participants was maintained through the study by having the participants provide their responses directly to the researcher. All data was stored in a locked cabinet and on secured storage devices. The Institutional Review Board (IRB) of Robert Morris University (RMU) approved the protocol for this research.

Instrumentation

The survey instrument was a modified survey questionnaire based on the critical success factor survey outlined in *CMU/SEI-2004-9TR-010: The critical success factor method: a foundation for enterprise security management* (Caralli, Stevens, Wilke, & Wilson, 2004). The survey asked participants to provide demographic information related to their gender, name of institution, business title and level, and number of years of experience in the field of research administration. Participants identified the information systems they currently used, key business functions, important goals and objectives within their area of responsibility, and problems or obstacles experienced while performing their duties as research administrators.

Data analysis

Data analysis began with the demographic nominal and ordinal information provided by the participants. Next, open-ended responses were categorized into major themes with repetitive answers consolidated. In vivo coding was utilized to create the categories. In vivo coding consists of using the words of the participant to create categories (Creswell, 2014; Bryman, 2012). The software application Nvivo® along with a spreadsheet application was used to code the open-ended participant responses. To ensure objectivity, an expert in the field of research administration that met the expert criteria and who did not participate in the survey reviewed the coded material to ensure consistency and validity (Creswell, 2014).

Results

The Delphi study began by selecting 149 potential participants using a direct sampling technique. Individuals holding leadership positions from a research administration professional organization provided the potential participant list. E-mail invitations were sent on a weekly basis to potential participants. Twenty-two participants (14.8%) met the required criteria and completed the survey. The demographic information of the participants is illustrated in Table 1. The gender statistics of the Delphi participants are comparable to the 2010 Research Administrator profile conducted by Shambrook and Roberts (2011).

Table 1: Delphi participant demographics

	Demographic data			
Gender	Male	Female	Unidentified	
	4 (18.2%)	17 (77.3%)	1 (4.5%)	
Carnegie Classification	Very High	High		
	15 (68.2%)	7 (31.8%)		
Academic Unit of employment	Department or College level	Central or University level		
	5 (22.7%)	17 (77.3%)		
Years of RA Experience	8 - 10 Years	11 - 13 Years	14 - 16 Years	17+ years
	2 (9.1%)	2 (9.1%)	3 (13.6%)	15 (68.2%)

Artifacts

Artifacts play a key part in the administration of research and the management and dissemination of knowledge. Schein (2010) defines artifacts as the physical products of a group such as:

> the architecture of the physical environment; its language; its technology and products; its artistic creation; its style, as embodied in clothing, manners of address, and emotional displays; its myths and stories told about the organization; its published list of values; and its observable rituals and ceremonies. (Organizational Culture and Leadership, p.23)

Certainly, research administrators across institutions of higher education have an established professional language, or jargon, to communicate with internal and external stakeholders. The physical space of offices, buildings, and the layout of a campus or organization influences the sharing of existing knowledge and the creation of new knowledge. More importantly, the division of labor and the vertical and lateral coordination of command and control, or organizational chart, create avenues or blockades to KM. Technology plays a major role in research administration.

Institutions use information systems and applications to manage sponsored research. These tools range from basic spreadsheet applications to customized electronic research administration (eRA) systems and institutional web sites. All 22 participants in the study listed at least two information systems they used to manage sponsored projects in their area of responsibility. Six of the 22 indicated using spreadsheet applications to augment institutional systems. The effective management and sharing of knowledge requires the artifacts of an organization or community of practice to be aligned with the goals of any KM initiative.

Espoused beliefs and values

Espoused beliefs and values represent the ideals, goals, values and aspirations of a population that have been validated and rationalized (Schein, 2010). Within the profession of research administration there exists a core set of beliefs and values that guide decisions, behavior and actions.

Table 2 illustrates the espoused values for research administrators participating in the study. The term 'accuracy' or the phrase 'to be accurate' was mentioned, on average, 2.72 times per participant. The value of building and maintaining positive relationships with all customers for research administration professionals and communication is consistent with previous literature (Kulakowski & Chronister, 2006). The categories of 'timeliness' and 'importance of reporting' allude to the research administrators' belief in organization and structure. Previous literature also indicates research administrators have a preference for, and value rules, authority, institutional boundaries, processes and systems (Derrick & Nickson, 2014; Atkinson & Gilleland, 2007). Campo, 2014, adds that in addition to communication, team building, and interpersonal skills, research administrators value a positive, can-do attitude, which is reflected in the importance of the category 'customer service'. Other values mentioned in previous literature but not included in the sample are the beliefs in strong character traits such as being ethical, principled, trustworthy, warm, supportive, and risk-averse. (Atkinson & Gilleland, 2007; Campbell, 2010; Campo, 2014; Derrick & Nickson, 2014; Lankford, 1997). The beliefs and values of the profession have a significant impact on what KM initiatives are pursued or terminated.

Table 2: Espoused beliefs and values of participants

	Number of times phrase was used	Percentage of Delphi participants using term
Accuracy	60	95.5%
Timeliness	46	81.8%
Communication	46	40.9%
Reporting (importance of)	37	77.3%
Customer Service	36	59.1%
Training	28	45.5%
Ease of access to information	13	59.1%
Relationships	11	50.0%
Tolerance (patience/flexibility)	5	22.7%
Humor	3	13.6%

Basic underlying assumptions

Basic underlying assumptions are different from prevailing, or strongly held values. Underlying assumptions represent the underlying patterns of behavior that have become so engrained in the actions, attributes, and mental models of the population that they are taken for granted and there is little variation within a social unit (Schein, 2010). Primary to the basic underlying assumptions concerning research administration is the ideal of service and servant leadership (Derrick & Nickson, 2014; Waite, 2001). This is collectively reflected in the statements of the sample population. Atkinson, Gilleland and Barrett (2007) support this position by stating that research administration is a profession because of the "ideal of service to clients and stakeholders, in addition to possessing specialized knowledge, and observing a code of ethics and principles" (The dimentions of influence on research administrator behavior: toward a theoretical model of research administration as a public service profession, p. 63). Gabriele & Caines, (2014) argue for the critical role research administrators play as servant leaders in the world of research itself. These basic underlying assumptions are critical and are at the center of knowledge management for organizations and professions. A commitment to the ideal of learning through sharing information must be an underlying basic assumption of the profession and organization for any KM activity. Lacking this quality requires a paradigm shift in the mindset of the population and sweeping cultural change.

Discussion

The cultural factors of artifacts, espoused beliefs and values, and basic underlying assumptions identify the elements of research administration that are crucial when initiating or evaluating knowledge management programs for the profession and the community of practice. Higher education institutions need to focus on mutual relationship and doing things together in order to have organizational knowledge management success (Nurluoz & Birol, 2011). "In higher education, knowledge management becomes a significant part of the quality improvement that

leads collaborative efforts of the professionals to share knowledge, construct knowledge in order to improve the efficiency for better work practices" (Nurluoz & Birol, 2011, p. 207). There is a significant amount of literature addressing knowledge management success in organizations to include the identification of critical success factors, best practices, principles, rules and applications. For the research administration community the practice four factors are essential to promote a learning culture.

First, organizational champions have to be identified and given the resources to lead KM initiatives (Davenport & Prusak, 1998; Kidwell et al., 2000). These advocates must be respected and outwardly represent the values and beliefs of the practice and symbolize the basic underlying assumptions of the profession through word and deed. Mas-Machuca examined the critical success factors of KM and found that trust, transparency, honesty, collaboration, professionalism, flexibility, and commitment were related to culture (p. 1308). These same qualities are essential for the knowledge champions of the organization. In addition, these stalwarts are simultaneously mentors, cheerleaders, defenders, marketers, and branding professionals who encourage the stimulation of knowledge collection and sharing. In essence, they are knowledge leaders.

Second, Davenport and Prusak (1998) state that in order to simply have knowledge shared and created, one needs to "put smart people in a room and let them talk." (p.16). Organizational structures need to facilitate the exchange of information through socialization to codify and transfer tacit knowledge (Nonaka, 1994). This is true for both institutions of higher education and the community of practice as a whole. This is accomplished by providing space for the assembly of research administrators at all levels within the institution and allocating sufficient time to present and share information. One manner to accomplish this task is to encourage research administrators to attend professional meetings. There are several United States-based professional organizations that hold meetings locally and regionally for research administrators at all levels. These organizations also hold an annual membership meeting. Meetings provide the opportunity to network with other professionals, enabling attendees to discover who possesses knowledge, to identify individuals seeking knowledge, and to engage in all four modes of knowledge transfer as indicated by Nonaka (1994).

Third, the use of technology enables the transfer of explicit knowledge. Along with individual institutions using technology to establish knowledge repositories, there are knowledge "banks" available within the profession. These systems allow the transfer information and explicit knowledge; however, they are considered "passive disseminators" with users only accessing them for specific information when needed (O'Dell & Grayson, 1998). Regardless of the database or knowledge repository utilized, users have to find value in the information. Users create knowledge by interpreting and giving meaning to the information stored on these systems (Steyn, 2004). The information system needs to be easy to navigate, robust, continually updated, and linked to existing work processes.

Lastly, as with any project or program, knowledge management initiatives have to be measured and assessed on a regular basis (Davenport & Prusak, 1998; Kidwell et al., 2000). This includes incentivizing and establishing a reward structure for seeking and creating knowledge to further the administration and management of research. The metrics or the evaluation of KM initiatives

should include both qualitative and quantitative measures for success (Davenport & Prusak, 1998). Additionally, the metrics should be tied to work processes, functionality, usability, and the strategic goals of the organization (Jennex, Smolnik, & Croasdell, 2009).

Further Research

The first round of results of the Delphi study identified information technology artifacts and espoused values of research administrators even though a direct line of questioning for these cultural elements was not the primary focus of the research project. Further research specific to these cultural elements should be investigated. Other cultural elements and the subculture and micro-culture levels of research administration should continue to be explored. The application of institutional, administrative behavior, and organizational theories related to the research administration community of practice could add depth of understanding to the profession.

Conclusion

The profession of research administration has developed in unprecedented ways since the end of the last world war. The knowledge required to successfully administrate research in institutions of higher education crosses multiple disciplines. The management of explicit and tacit knowledge is essential for the continued growth and development for the profession. Organizational culture plays a significant role in the success or failure of these projects. By applying organizational cultural theory and gaining an understanding of the artifacts, espoused values and beliefs, and basic underlying assumptions, research administrator knowledge leaders can identify and address potential obstacles to the successful transfer and creation of knowledge for their organization, the community of practice and the profession of research administration.

Authors' Note

The data and findings presented in this paper are the results from the first phase of a Delphi study, which was part of a larger exploratory sequential mixed-methods study for the author's doctoral dissertation.

Dwayne W. Lehman, D.Sc.
Business Manager, Human-Computer Interaction Institute (HCII)
Carnegie Mellon University
5000 Forbes Ave.
Pittsburgh, PA 15213
(412) 736-8485
Email: dwlehman@mac.com

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More and Better Grant Proposals? The Evaluation of a Grant-Writing Group at a Mid-Sized Canadian University

Natasha G. Wiebe
University of Windsor

Eleanor Maticka-Tyndale
University of Windsor

Abstract: *Obtaining external funding has become increasingly difficult for Canadian researchers in the social sciences and humanities. Our literature review suggests that grant-writing groups and workshops make an important contribution to increasing both applications for external funding and success in funding competitions. This article describes an 8-month grant-writing group for 14 social scientists in a mid-sized Canadian university. The goal was to increase applications and successes in funding competitions. The group integrated several strategies perceived by Porter (2011b) to encourage more and better grant proposals: offering "homegrown" workshops that were ongoing rather than occasional, sharing successful proposals, coaching and editing, bringing together emerging researchers with established ones, and placing participants in reviewers' shoes. These strategies were combined in a series of monthly sessions that required participants to write each section of a grant proposal and share it with others for feedback. Participants perceived this approach to work well; it appeared to provide useful feedback and examples, and develop a sense of accountability and community. The number of applications submitted for funding increased 80% from the funding cycle just prior to the group (2013-2014) to the funding cycle during or immediately after the group (2015-2016). The rate of success in obtaining funds from internal and external grant submissions increased from 33% to 50% over this same time period. The greatest increase in submissions and success were experienced by emerging and alternative academic researchers. From their program evaluation, authors conclude that grant-writing groups are a useful way to build researcher confidence and commitment to submitting proposals to funding competitions and contribute to success, especially for researchers with limited experience in such competitions.*

Keywords: *Academic writing; alternative academics; grant-writing groups; grant writing; program evaluation; writing workshops*

Introduction

External or extramural funding is essential to conducting much academic research and, in many departments with graduate programs, to providing financial support and research experience for graduate students. Success in obtaining such funding also enhances the reputation of researchers and their universities. However, in Canada, obtaining external funding has become increasingly difficult for researchers from the social sciences and humanities due to a serious decline in granting-council funding in inflation-adjusted dollars since 2007 (CAUT, 2013). The corresponding decline in grant success rates makes identifying and implementing strategies for increasing success in funding competitions ever more important for researchers and universities alike. This article describes implementation of one such strategy, an 8-month grant-writing group at a mid-sized Canadian university. The goal of the grant-writing group was to increase submissions and success in external funding competitions among researchers in humanities and social science related disciplines with three specific objectives: (a) to strengthen grant-writing skills of participants; (b) to increase submissions to both internal and external funding competitions, recognizing the importance of internal funding as a launchpad for external grants; and (c) to increase success rates in funding competitions. The grant-writing group strategy is presented here within the context of the literature on predictors of, and strategies to enhance, success in external funding competitions and various indicators of the degree of success of the group in meeting its objectives.

Literature Review

Method

Literature on enhancing success in external funding is found primarily in the field of research administration. To find relevant literature in this field, we searched tables of contents of major journals (e.g., *Journal of Research Administration, Research Management Review, Journal of the Grants Professionals Association*) as well as the reference lists of articles. While this literature includes grant-writing workshops among the strategies for enhancing success, we had to turn to the creative writing literature for details related to the methods, strategies, and dynamics of writing groups. We relied on books on creative writing and writing groups, and expanded outward using references from these books.

This approach produced 39 articles and one book chapter summarized in Table 1. Thirty of these focused on success in obtaining external funding, and 13 addressed the dynamics of writing groups. Lead authors included 12 who were in administrative positions at universities or research organizations and 16 faculty members. The administrators were more likely to publish several articles while faculty most often published only one. Most publications came from research or experiences in the United States, with one from Australia, two from Canada, and one from Uganda. The 30 publications that addressed strategies to enhance success covered three thematic areas: (a) predictors of success (n=6), (b) what can or has been done by colleges and universities to enhance success (n=16), and (c) barriers to and enablers of submitting funding proposals (n=8). Of the 13 publications that specifically addressed writing groups, four focused on writing for funding, and the remainder on writing for postsecondary courses or publication.

Table 1. Summary of Literature Reviewed.

Author	**Date**	**Journal or Book Not determined**	**Theme**
Badenhorst et al. (Canada)	2013	All Ireland Journal of Teaching and Learning in Higher Education	Writing groups
Badenhorst et al. (Canada)	2016	Canadian Journal of Education	Writing groups
Banta et al.	2004	Journal of Research Administration	Strategies to enhance success; writing groups
Boyer & Cockriel	1998	SRA Journal	Individual barriers & enablers
Boyer & Cockriel	2001	Journal of Research Administration	Individual barriers & enablers
Bruffee	1984	Writing centers: Theory and administration (Olson, ed.)	Writing groups
Bryan	1996	Journal of Adolescent & Adult Literacy	Writing groups
Carr, McNicholas, & Miller	2009	Research Management Review	Barriers to success
Dingerson	1977	Journal of Higher Education	Strategies to enhance success
Dooley	1994	Research Management Review	Individual barriers & enablers
Dopke & Crawley	2013	Journal of Research Administration	Writing groups; strategies to enhance success
Easter & Schultz	1998	Research Management Review	Strategies to enhance success
Easterly & Pemberton	2008	Research Management Review	Individual barriers & enablers
Frantz	2013	Research Management Review	Writing groups; strategies to enhance success
Friend & Gonzalez	2009	Academe	Writing groups
Gibson	2015	Journal of the Grant Professionals Association	Strategies to enhance success
Houfek et al.	2010	Nurse Educator	Writing groups

Kleinfelder, Price, & Dake	2003	American Journal of Health Education	Individual barriers & enablers
Liebert	1977	Journal of Higher Education	Predictors of success
Linder et al.	2014	Innovative Higher Education	Writing groups
Mishler	1988	Research Management Review	Strategies to enhance success; Institutional strategies
Mishler	1989	Research Management Review	Strategies to enhance success; Institutional strategies
Monahan	1993	SRA Journal	Individual barriers & enablers
Monahan & Fortune	1995	Research Management Review	Predictors of success
Muffo & Coccari	1982	Research in Higher Education	Predictors of success
Muir	1979	Research in Higher Education	Predictors of success
Neumann	1978	Research in Higher Education	Predictors of success
Nguyen & Meek (Australia)	2015	Journal of Research Administration	Strategies to enhance success; Institutional strategies
Porter	2004	Journal of Research Administration	Strategies to enhance success
Porter	2007	Journal of Research Administration	Strategies to enhance success
Porter	2011a	Research Management Review	Strategies to enhance success
Porter	2011b	Research Management Review	Strategies to enhance success
Salas-Lopez et al.	2011	Journal of General Internal Medicine	Writing groups
Schumacher	1994	Research Management Review	Strategies to enhance success
Sisk	2011	Journal of the Grant Professionals Association	Strategies to enhance success

Steinert, McLeod, Liben, & Snell	2008	Medical Teacher	Writing groups
Tumwijukye et al. (Uganda)	2013	Journal of Research Administration	Strategies to enhance success
Walden & Bryan	2010	Journal of Research Administration	Individual barriers & enablers
Whitney	2012	English Journal	Writing groups
Wolfle	1982	Research in Higher Education	Predictors of success

Strategies to Enhance Success in Obtaining External Funding

Several authors identified the 1970s as a time when American postsecondary institutions were turning increased attention to external funding for research (Liebert, 1977; Mishler, 1988; Muir, 1979). Literature during this period followed two lines of inquiry, both of which have continued on to the present. The first is publications by administrators about strategies for postsecondary institutions to increase funding success (Banta et al., 2004; Dingerson, 1977; Dopke & Crawley, 2013; Easter & Schultz, 1998; Frantz, 2013; Gibson, 2015; Mishler, 1988, 1989; Porter, 2004, 2007, 2011a, 2011b; Schumacher, 1994; Sisk, 2011; Tumwijukye, Motevalli, Nambi, & Kyeyune, 2013). The second is publications written almost exclusively by faculty identifying individual, disciplinary and institutional predictors of success in competitions (Liebert, 1977; Monahan & Fortune, 1995; Muffo & Coccari, 1982; Muir, 1979; Neumann, 1978; Nguyen & Meek, 2015; Wolfle, 1982). Publications addressing barriers and enablers to grant writing began to appear in the 1990s (Boyer & Cockriel, 1998, 2001; Carr, McNicholas, & Miller, 2009; Dooley, 1994; Easterly & Pemberton, 2008; Kleinfelder, Price, & Dake, 2003; Monahan, 1993; Walden & Bryan, 2010). Since 2000, these have been joined by numerous publications and internet-based materials, workshops, and webinars on how to write successful funding proposals. To keep the literature review manageable, and to maintain a focus on scholarly publications, these latter resources were not included in this review. The 13 resources on writing groups addressed how such groups benefit writing; four specifically writing for funding (Banta et al., 2004; Dopke & Crawley, 2013; Frantz, 2013; Houfek et al., 2010), and the remainder writing for postsecondary courses and/or for publication (Badenhorst et al., 2013; 2016; Bruffee, 1984; Bryan, 1996; Friend & Gonzalez, 2009; Linder, Cooper, McKenzie, Raesch, & Reeve, 2014; Salas-Lopez et al., 2011; Steinert, McLeod, Liben, & Snell, 2008; Whitney, 2012).

Predictors of Success

The earliest publications focused on identifying predictors of success with theories of meritocracy, institutional reputation, size, resources and privilege, as well as disciplinary differences the focus of these inquiries. Meritocracy, measured as the number of peer-reviewed publications by individual faculty members or prior funding success by institutions, was a significant predictor of

success in external grant competitions for both individuals (Liebert, 1977; Neumann, 1978) and institutions (Wolfle, 1982). The size of the effect, however, was shown to vary by: (a) discipline, with funding in chemistry, for example, more strongly influenced by meritocracy than funding in sociology (Neumann, 1978); (b) recency, with recent publications having a stronger effect on funding success than career total (Liebert, 1977); and (c) the stature of the funding agency, with a stronger effect on success in applications to 'major' than 'minor' league agencies (Liebert, 1977). Regardless of the number of publications of the researcher, disciplines differed in the funding their faculty garnered, reflective of differential costs of research and the sources of funding available (Liebert, 1977; Neumann, 1978). At the institutional level, Wolfle (1982) also demonstrated that the number of graduate programs positively influenced the amount of external research funding across the institution irrespective of indicators of prior performance by a researcher.

Although multiple other factors were found to influence external funding success when examined individually, prior performance, discipline, and emphasis on graduate education were the only predictors that retained statistical significance when multivariate analyses were conducted (Liebert, 1977; Muffo & Coccari, 1982; Muir, 1979; Wolfle, 1982).

Institutional Strategies

John Mishler (1988) outlined a three-level strategy for small to mid-sized colleges and universities transitioning from a focus on teaching to an enhanced focus on externally funded research. Mishler stressed the importance of the institutional commitment and preparation of a mission statement, long-range strategic plan, and goal setting that reflected the shift toward increased research (1998, p. 19). A critical component of each was enhancing infrastructure at the institutional and departmental levels. At the institutional level, this included development of an administrative research unit; provision of internal research grants, modern laboratory space and equipment, and graduate research assistants; and research support from non-academic units such as computing services. At the level of the academic unit or department, incentives were included for faculty such as enhancement of salaries and reduced teaching loads, department goal-setting related to research, and identification of centres of excellence. At the level of individual faculty members, skills enhancement were included (e.g., through attending workshops or seminars sponsored by the department or administrative research unit, partnering with established researchers for proposal review) and participation in centres of excellence.

Several strategies described by Mishler (1988) have been examined in detail by other authors. The prime incentives documented by Michael Dingerson (1977) and Marilyn Banta et al. (2004) included internal research grants for small or pilot projects to develop and demonstrate competence, test or refine research procedures or instruments, and contribute to publications, all of which enhance the profile and competitiveness of researchers in funding competitions. T.L. Huong Nguyen and Vincent Meek (2015) stressed the need for administrative infrastructure to support research, especially in universities in low-resource settings. Workshops were included in almost all the literature as an important approach for building skills, providing information, enhancing motivation, and establishing supportive, mentoring relationships. Banta et al. (2004) provided an overview of their experience in a two-year fellowship program at a Colorado

university that included both a financial incentive and workshop program in the form of luncheon meetings and retreats, formal mentoring relationships, and a quality review team that reviewed the two external funding proposals that fellows were expected to submit over the course of the program. Robert Porter highlighted the importance of ongoing, in comparison to single or occasional, workshops for developing grant-writing skills and a grant-writing culture (e.g., 2004; 2011b). Polyanne Frantz (2013) described how a culture of grant-writing was created in faculty writing groups using a faculty learning commons model. Porter (2011b) further described how workshops and additional strategies, such as visits by grant program officers, sharing successful proposals, mock review panels, coaching and editing, mentor matchmaking, online tutorials, department writing retreats, and awards newsletters, could increase participation and success in funding competitions. These strategies were central to the curriculum in grant-writing courses described by Anne Sisk at the University of Rochester in the United States (2011) and Henry Tumwijukye and colleagues at Makerere University in Uganda (2013). Finally, the role of grant program officers and others in providing training, coaching, and encouragement was highlighted not only by Mishler (1988) and Porter (2011b), but also by Linda Easter and Eileen Schultz (1998) and Nicole Gibson (2015). Easter and Schulz (1998) detailed the contribution made by a standing committee that worked with faculty and increased the number of proposals submitted and funding received at a Pennsylvania university.

Individual Barriers and Enablers

Articles describing barriers and enablers to success were similar in focus to the earlier "predictors of success," but relied on faculty reports without considering their association with actual success. The most commonly reported barrier was time constraints. Most faculty reported being too busy to allocate time to preparing grant applications, citing heavy teaching loads, committee work, and pressure to publish (Dooley, 1994; Kleinfelder, Price, & Drake, 2003; Monahan, 1993; Monahan & Fortune, 1995). This was more often the case for non-tenured than tenured faculty (Walden & Bryan, 2010) and female than male faculty (Easterly & Pemberton, 2008). Other barriers included lack of familiarity with the grant process and lack of understanding of budgeting (Boyer & Cockriel, 1998; 2001), as well as lack of awareness of services provided by research offices in their institutions (Easterly & Pemberton, 2008) and the perception that writing grant proposals created more work with no direct financial benefits accruing to faculty (Walden & Bryan, 2010).

Enablers of increased submissions to external funding agencies included reduction in teaching load for the express purpose of writing grant applications, salary incentives for successful applications, inclusion of proposal submissions and success in tenure and promotion decisions, funds to travel to meet with peers and funding agencies in preparation for writing proposals, and institutional support both in educating faculty on the inner workings of the funding world and in developing the skills for writing successful grant applications (Boyer & Cockeriel, 1998; Dooley, 1994; Easterly & Pemberton, 2008; Kleinfelder, Price, & Dake, 2003; Monahan, 1993; Walden & Bryan, 2010). Walden and Bryan further identified awareness of the benefits that accrue with external funding as enablers to preparing applications (2010). These included increased research autonomy, funds for personnel support in the form of graduate assistants and clerical staff, flexibility in how time is allocated, and enhanced professional reputation. They suggested

an additional enabler or incentive would be to allocate a portion of the discretionary and indirect funds associated with external grants directly to faculty (2010, p. 91).

Writing Groups

The 13 resources that we used on writing groups came primarily from English and creative-writing departments in American postsecondary institutions, with some from writing for research publications in health and education. Several authors emphasized the importance of the social dimension of writing groups for enabling or improving writing, building confidence, and/or maintaining commitment to the group (Badenhorst et al, 2016; Bruffee, 1984; Frantz, 2013; Linder et al., 2014; Salas-Lopez et al., 2011; Steinert et al., 2008). Commitment to group objectives and accountability were identified as essential to group success (Bryan, 1996; Banta et al., 2004; Frantz, 2013; Linder et al., 2014). These are fostered through collaboration among group members initiated during what Debbie Salas-Lopez and colleagues referred to as the "forming stage" (2011, p. 113). It is during this stage that personal relationships become solidified, allowing writing-group participants to feel safe and a general sense of acceptance Participants in a writing group for new Education faculty at Memorial University, Canada, reported that the sense of safety and support system that emerged within their group led to increased productivity. Members successfully applied for funding for their own research (Badenhorst et al., 2013), and published collaboratively and individually (2016). From a review of published accounts of writing groups, the Memorial University team concluded that writing groups increase writing productivity (Badenhorst et al., 2013). However, the value of writing-groups may extend beyond enabling writing by providing a venue where new faculty may discuss broader issues such as "the politics of writing, the nuances of the tenure process, and even pedagogical practices" (Friend & Gonzalez, 2009, para. 2).

Julia Houfek and colleagues (2010) proposed writing groups as a strategy for faculty at a Nebraska College of Nursing to overcome barriers such as poor time management and procrastination (contributing to claims of time constraints), as well as negative emotions associated with writing (e.g., fear of rejection or inadequacy, anxiety, lack of confidence). Time constraints and procrastination were counteracted with the scheduling of group sessions and the homework expectations for work to be shared at sessions. Negative emotions were addressed through the co-mentoring element of writing groups. Anne Whitney, referencing experience with a writing group for public school teachers, credited group celebrations of success with counteracting what she refers to as "the dandelion feeling" (2012, p. 52), that is, a feeling that if you succeed too much you will be chopped down by colleagues like the dandelion flower that stretches above the grass. From a literature review on writing groups in higher education, Celeste Badenhorst and colleagues observed that such groups are proposed to address challenges facing academic writers, such as alienation, isolation, anxiety, and balancing teaching, research, and service (2016).

Ten of the 16 sources on strategies to enhance success in funding competitions identified grant-writing groups and writing workshops or courses as making an important contribution to increasing both applications for external research funding and success in funding competitions (Banta et al., 2004; Easterly & Pemberton, 2008; Frantz, 2013; Houfek et al., 2010; Mishler, 1989;

Monahan, 1993; Porter, 2004; 2011b; Sisk, 2011; Tumwijukye et al., 2013). Authors perceived groups and/or workshops as counteracting many barriers identified by faculty to preparing funding proposals, as well as including both many enablers of funding proposals and the general benefits of writing groups. The remainder of this article describes a grant-writing group that met during the 2014-2015 academic year at a mid-sized Canadian university.

Setting: University of Windsor

The University of Windsor, Canada's southernmost university, is located in the city of Windsor on the Ontario-Michigan border. This mid-sized, comprehensive university has over 12,780 full-time and part-time undergraduates, 2,794 graduate students, and over 500 researchers in 9 faculties (University of Windsor, 2016). The university implemented a centralized research administration infrastructure in the 1980s. Since 2007, the Office of Research & Innovation Services has grown from four staff reporting to the Associate Vice-President, Research, to five staff and one senior administrator under the direction of the Vice-President, Research & Innovation. Since its inception, the office has supported research through institutional-level supports consistent with those described by Mishler (1988): managing internal grant programs, fostering partnerships with local industry, and coordinating the development of campus-wide research objectives. Initially, the small office reviewed institutional grant applications, and checked other applications for completeness and correctness before mailing them to funding agencies. Around 2007, the growing office began transitioning to a professional services model, where research coordinators engage in diverse activities designed to encourage researchers to write more and better grant proposals. These activities include those recommended by Porter (2011a, 2011b): publishing a grant newsletter; speaking at departmental meetings and facilitating workshops; collecting and sharing successful proposals; providing guidance and editorial advice for strengthening applications; and piloting a research leadership chair program in the faculties, with some positions designed to mentor colleagues in grant writing. In addition to the institutional-level activities of the Office of Research & Innovation Services, some faculties and departments encourage research and grant writing through workshops and brown-bag lunches, internal grant programs, and informal and formal peer review. The Faculty of Arts, Humanities, and Social Sciences, for instance, requires that all applications for external funding be reviewed by the Associate Dean, Research and Graduate Studies. This position was created in 2002 to enhance success in external funding competitions. In 2014-2015, the Faculty of Arts, Humanities, and Social Sciences partnered with the Office of Research & Innovation Services to facilitate a grant-writing group for researchers from across the University of Windsor.

The Grant-Writing Group

The University of Windsor grant-writing group for social sciences and humanities was offered to 14 researchers who responded to an open invitation in the 2014-2015 academic year: 4 established researchers (mid to late career); 6 emerging researchers (5 years or less into a tenure-track or tenured position); and 4 alternative academics (PhDs in academic positions other than tenure-track or tenured). With the exception of two guest speakers, workshops were facilitated by the Associate Dean, Research and Graduate Studies and a research coordinator from the Office

of Research & Innovation Services (authors Maticka-Tyndale and Wiebe). Sponsors hoped the grant-writing group would increase both the number of grant applications and the number of successful applications at the University of Windsor.

Participants generally met in a University of Windsor workshop room between 10 a.m. and noon on one Friday each month from November 2014 to June 2015. We chose Fridays because it was the weekday with the fewest scheduled classes. Most sessions were divided between work-in-progress groups and a workshop. Participants were invited to share their homework with us between sessions for additional feedback. We encouraged participants to bring their full grant proposals to the Office of Research & Innovation Services Writing Retreat in August 2015, where they could participate in mock review panels and finalize their proposals using reviewer feedback. Moreover, we invited participants to submit their finished proposals for a $5,000 award for the best proposal offered by the Office of the Dean, Faculty of Arts, Humanities, & Social Sciences.

The grant-writing group followed a consistent teaching format. Each two-hour session began with about 50 minutes during which participants discussed their homework in groups of two to four (depending on attendance), with members identifying strengths and making suggestions for improvement. We paused midway for a 10-minute refreshment break, and concluded with a workshop that introduced a new topic and assigned homework due by the next session (e.g., write a one-page knowledge mobilization plan).

Methods to Assess Success in Achieving Objectives

Our program evaluation used four sources of data to assess the success of the grant-writing group in meeting its objectives: (a) participation records, (b) exit tickets, (c) a survey of participants, and (d) institutional data on submissions to internal and external funding competitions and success in these competitions. Participation records consisted of attendance records for each meeting, homework submissions to the group leaders, and submissions to the competition for the best proposal. These records were used as indicators of the level of sustained participation in the group. Exit tickets completed by participants at the end of each group session asked for anonymous feedback from participants on what went well and what could be improved. Two months after the last session in June, surveys were distributed to all participants (see Appendix 1). (We had planned to distribute the survey immediately following a mock review-panel session in August, but this event was cancelled due to low registration.) Participants were asked to (a) rate how well 6 aspects of the group process (e.g., format, time for peer feedback, homework) and 9 characteristics of the sessions (e.g., refreshments, location), worked for them on a scale ranging from "didn't work at all" to "worked extremely well"; (b) rate the frequency of 8 personal experiences (e.g., feeling comfortable sharing work, feeling responsibility to do homework) from "never" (1) to "always" (5); and (c) assess whether their writing skills were strengthened in 9 areas required in grant proposals (e.g., statements of significance, student training plans, budget justification) and whether there were changes in 8 areas related to writing proposals (e.g., adopted new writing habits, feel more confident in applying for a grant) both rated as "yes," "no," or "not sure." In addition, space was provided following each series of questions and at the end of the survey for open-ended comments. Given the small size of the group (n=14), no questions were

asked about discipline, stage of career, or any other personal identifying information, in order to maintain confidentiality. Reminders to complete the surveys were sent via email at the end of August. The exit tickets and surveys were used to assess participants' subjective evaluation of specific administrative, logistical, pedagogical, and content characteristics of the grant-writing group and its usefulness and effect for them. The final source of data was university records on grant submissions and outcomes. These records comprised the "hard data" to assess whether the grant-writing group met its goal of increasing applications and successes in research funding competitions. These evaluation procedures were reviewed and approved by the university's Research Ethics Board.

Results

Participation

While many of our researchers are part-time residents of Windsor who leave for home on Thursday evenings, our grant-writing group averaged 79% attendance (11 of 14 participants). Attendance dipped to an average of 57% during the last two months (6.5 of 14 participants) due to conflict with a holiday weekend, the end of the academic year, and the onset of conference season. We began the group with 17 members, which stabilized at 14 after the first 3 months. Of these 14 members, 3 attended only half of the 8 sessions. Two of these were new hires who came directly from PhD programs into departments with faculty resources that were so depleted that they needed to focus on teaching responsibilities for at least two years. The remaining 11 participants attended an average of 6.5 of 8 sessions. The generally good attendance attests, in part, to a schedule that worked "extremely well" according to responses on the survey. "[I like] keeping my grantmaking ambitions *on timeline*," wrote one participant on an exit ticket. "Getting me out of the house today was useful," noted another. "I need structure.... I want to have writing time but I allow other things to interfere." Yet another participant emailed to say that "Meeting once per month forces us to space out the grant writing process and not to crunch all the work that needs to be done in the few weeks prior to grant application deadlines."

Two of three survey respondents noted that, as a result of their participation in the grant-writing group, they would begin working on proposals six months in advance of the deadline. However, the larger pattern of group writing behaviour suggests that these good intentions may not be realized. From the first workshop, group members were aware that $5,000 would be awarded to the best grant proposal. During the penultimate workshop, we announced the August deadline for this competition. Nearly half of the grant-writing group (6 of 14) registered for an optional two-day writing retreat in late August, during which they could share their finished proposals with other participants on mock adjudication committees and revise their proposals for submission for the award. The session was cancelled, however, due to last-minute withdrawals. Moreover, only one-third of members (5 of 14) submitted proposals for the $5,000 award in August, although nearly two-thirds (9 of 14) could have submitted the same proposal that they had already submitted to another competition during the grant-writing group. Two of the five proposals that were submitted for the dean's award did not meet reviewer expectations. Finally, while we averaged a 50% response rate on exit tickets for each workshop, only 21% of group members

(3 of 14) submitted surveys of the grant-writing group by the August deadline. This suggests that, without the structure of our ongoing monthly meetings, participants lost momentum on their proposals. All survey respondents agreed that "The group meetings and assignments have made developing a grant proposal more manageable." Our group appeared to help participants overcome the common barrier of time constraints, but only while the group was in session.

Teaching Approach: Work-In-Progress Groups

Participants commented on the division of group meetings into *work in progress* and *workshop* sessions on both exit tickets and the survey. The survey indicated that, generally, this format worked "extremely well," and exit tickets suggested that the format was useful in that it was "grounded in the reality of grant proposal instruction" and provided a "good balance between active learning & active listening."

Twenty-five percent of comments volunteered on exit tickets concerned the work-in-progress groups (46 of 182 comments) with participants generally positive in their comments. Over half of the comments on the work-in-progress groups (25 of 46 comments) highlighted the usefulness of sharing proposals and receiving feedback from peers. Common responses included "It's a great experience to read, explain, justify my own proposal to people: face-to-face, from other different fields, with different experiences" and "Group feedback was very helpful. My perspective is narrow, so I really appreciate hearing other points of view. My proposal will be better as a result." The survey indicated that suggestions for writing from the work-in-progress groups mostly worked, that respondents almost never felt uncomfortable sharing their writing, that respondents always felt comfortable making critiques of the work of others, and that respondents almost always felt safe receiving critiques from others. Moreover, respondents reported they almost always felt a responsibility to do their homework because they were presenting it to their group, and they almost always felt responsibility to attend the group even when they were unable to do their homework. In keeping with the literature on writing groups, the work-in-progress groups seem to have enabled writing and maintaining commitment to the group (Bruffee, 1984; Salas-Lopez et al., 2011; Steinert et al., 2008).

Comments about what was useful about the work-in-progress groups outnumbered suggestions for improvements to those groups by almost 3 to 1 (25 positive comments: 9 suggestions for improvement). We modified procedures based on suggestions for improvement together with our own observations. For example, we noted that some groups focussed on describing strengths in the proposals and made few suggestions for improvement. In the exit tickets, one participant thanked us for "making us switch groups," and another asked for examples of feedback that the facilitators would offer. Accordingly, we decided to facilitate some intermingling of the groups. We also began to spend time with each group each week. Twenty-four percent of exit-ticket comments on the work-in-progress groups said that participants liked having one or both facilitators join group discussions (11 of 46), and the surveys said these visits worked well. In addition, we began to invite participants to share their homework with us between meetings for our feedback, if desired, and 79% of participants (11 of 14) did so at least once. Respondents to the survey perceived that sharing writing with facilitators outside the group worked extremely well. One participant

emailed to say that "Preparing a section of our grant application for each workshop and having the possibility to discuss it with peers has provided us with valuable feedback. Combined with the one you also give us, the feedback allows us to have stronger applications."

Teaching Approach: Workshops

Twenty-one percent of exit-ticket comments related to workshop format (17 of 81) concerned the usefulness of examples and handouts, although we learned at an early stage that we needed more examples of successful humanities proposals. Seventy-nine percent of comments concerning specific workshops (33 of 42) indicated that the participants liked a particular aspect of a workshop (e.g., "I learned how to separate goals & objectives and how to structure them in a more concise fashion. Thanks!"; "Liked help with *specifics* on daunting topics: KM/KT & budget"). The workshop that received the fewest "likes" was that on research methodology. This is perhaps because of the wide diversity in methodologies used across the humanities and social sciences, making it impossible to do justice to them all. The workshops that received the most positive comments were those on student training plans and knowledge mobilization/translation plans. About midway through the grant-writing group, exit tickets began to request content for coming workshops or suggest ways to strengthen the delivery of a specific workshop (e.g., "For training RAs are there any rules of thumb on how long different aspects of training take?"; "An opportunity for large group input on key lessons learned or key tips from review of methodology section would be helpful"). Exit tickets were uncharacteristically specific about stating participant needs for the final workshop on budget justifications (e.g., "I would like some info on navigating U of W's finance system"; "provide us with estimates for the different budget items"; "discuss budgets for conferences/events as well"). This development may be because participants found grant budgets to be particularly challenging. However, the request for specific content to be covered during the final workshop is part of a general pattern of increasing requests for specific content and improvements during the grant-writing group. This development may be evidence of a growing sense of community and safety much like that experienced by the writing groups of Salas-Lopez et al. (2011) and Badenhorst et al. (2016).

In summary, in terms of teaching approach, participants reported the work-in-progress groups worked well. While requiring some fine-tuning (e.g., rotating members, incorporating visits from facilitators), the groups seem to have enabled grant writing, in part by creating accountability among participants. The groups also provided feedback from outside the writers' disciplines that writers mostly found useful. Participants responded positively to examples and handouts shared during workshops. As a sense of community developed, participants became more vocal and specific about what worked in terms of workshop strategies and what content they would like to see if subsequent sessions.

Teaching Approach: Lessons Learned

As workshop facilitators, we learned several important lessons about running such workshops. Commitment and attendance appeared to require regularity in the schedule, that is, that meetings occur monthly without interruption. Despite prior commitments and enthusiasm about a final

workshop during which participants would function as a grant review panel, after a two-month break in meetings, we cancelled this due to low registration, and surveys distributed after this break received a low response rate (3 of 14). Momentum appears to have been lost. To ensure regularity of meetings, attention must be paid to the natural breaks or interruptions that occur during an academic year such as exam periods, holidays, and conference season, with group meetings working around these. Moreover, to help members sustain their writing momentum after the group, administrators could encourage them to designate other events at the university for grant writing (such as writing retreats), or develop a writing group for returning members.

The division of sessions into work-in-progress group meetings and the more didactic introduction of new material appeared to work well. Both positive comments and suggestions for improvement from group members focused primarily on the work-in-progress groups. From this we gleaned several possibilities for future writing groups. These include inviting work-in-progress groups to debrief on their discussions with the group at large during each meeting; requiring members to submit draft proposals to facilitators mid-way through the program for feedback; and informing members of the final mock-panel review during the first group session, so that the entire group is spent preparing for this cumulative event.

Outcomes for Group Members

The specific objectives of the grant-writing group were to use a series of workshops to (a) strengthen the grant-writing skills of participants; (b) to increase submissions to both internal and external funding competitions; and (c) to increase success rates in funding competitions. Did the group realize these objectives?

Skills Development

There were no comments about skills development volunteered on the exit tickets. However, one participant emailed to say that they developed "good grant writing reflexes during the last months. I used them in the last external and internal grant applications I made and one of them was successful." Moreover, respondents to the survey perceived that they had significantly strengthened their skill in writing (a) for people outside their fields of research, (b) project/goals/objectives, (c) statements of significance, (d) outcomes, (e) theoretical frameworks, (f) methodology sections, (g) student training plans, (h) knowledge mobilization/translation plans, (i) budget justifications, and (j) an entire grant proposal. Respondents also agreed they were better prepared to offer other writers constructive, meaningful feedback on their grant proposals. In addition, two of the three respondents said that, as a result of participating in the group, they have adopted some positive new writing habits and are more confident about applying for a grant. This aligns with Houfek et al.'s (2010) observation that writing groups can overcome barriers such as lack of confidence.

Table 2. Number of Proposals Submitted and Successes in Receiving Funding in Internal and External Funding Competitions.

		2013-2014 Pre-GWG		2015-2016 post-GWG	
		submissions	**successes**	**submissions**	**successes**
internal grants	emerging & alternative	0	0	7	4
	established	3	2	4	3
	total	**3**	**2**	**11**	**7**
external grants	emerging & alternative	1	0	2	1
	established	5	1	3	0
	total	**6**	**1**	**5**	**1**
all grants	emerging & alternative	1	0	9	5
	established	8	3	7	3
	total	**9**	**3**	**16**	**8**

Notes: emerging & alternative researchers n=10; established researchers n=4

Grant Success: Submissions to Funding Competitions

The second objective for the grant-writing group was to increase submissions to both internal and external funding competitions. Table 2 provides data on both submissions and successes in applications to funding competitions during the 2013-2014 funding cycle immediately before (pre-GWG) and the 2015-2016 cycle during and immediately after (post-GWG) the grant writing group for the 4 established and 10 emerging and alternative academic researchers. Submissions to competitions increased by 80% (from 9 to 16) from the pre- to the post-GWG cycles. This increase was accounted for primarily by submissions of emerging and alternative academic researchers who had little experience in submitting applications prior to the grant-writing group and increased ninefold to the period during and after the group (from 1 to 9). The established researchers maintained a relatively "steady state" with eight submissions before and seven during and after the grant writing group. Thus, the second objective was met for emerging and alternative researchers, i.e., submissions to funding competitions were increased. The rate of submission for established researchers may well be at an appropriate maximum, averaging two or nearly two submissions per person in each of these funding cycles.

Internal Grant Success

Submitting to grant programs at one's own university has traditionally been advocated as a good way for new researchers to build their research programs and history of funding success. Internal grant programs are also an important source of support for many established social science and humanities researchers who require only small amounts of funding for research assistance or travel. In 2015-2016, researchers from the social sciences and humanities submitted 45 applications to 3 internal grant programs administered by the Office of Research & Innovation Services at the University of Windsor. Of these applications, 30 were successful. Of the 14 grant-writing group members, 11 applications were submitted to the same programs. Of these, 7 were successful, producing a near equal success rate for group participants and the general university population.

The internal grant success rate of the four established researchers in the grant-writing group showed only a slight increase with two of the three submissions prior to the grant writing group and three of the four after the group successful in receiving funding, higher than the success rate for the general university population. The group members who were less experienced with grant writing progressed from no submissions prior to the group to seven submissions with four successes after. Although the rate of success was higher for the established than the emerging and alternative academic researchers, it is noteworthy that the researchers who were less experienced with grant writing achieved a near 60% success rate with their applications.

External Grant Success

The University of Windsor has over 330 researchers who are eligible to submit grant proposals to the Social Sciences and Humanities Research Council (SSHRC), the largest source of funding available to them in Canada. In the 2015-2016 funding cycle, University of Windsor researchers submitted 16 applications to SSHRC Insight Development Grant competitions, of which 6 were successful. Five of these were submitted by grant-writing group members with one of these successful in obtaining funds. Of note is that the successful submission was by an emerging researcher who had not been successful in the past.

Group success rates in internal and external submissions combined suggest the grant-writing group met both its first and third objectives, improvement in grant-writing skills and increased success in funding competitions. The group's overall success rate increased from 33% before the group to 50% afterward. The success rate of the emerging researchers and alternative academics within the group increased from 0 to 55% (0 of 1 application funded before, 5 of 9 afterward). Similarly, the success rate of established researchers increased from 37% to 43% (3 of 8 applications funded before, 3 of 7 after). These successes are in keeping with Porter's perception that ongoing workshops help to develop grant-writing skills among participants (2004, 2011b).

In summary, the grant-writing group met its objectives to help (a) participants strengthen grant-writing skills, (b) increase submissions to internal and external funding competitions, and (c) increase success rates in funding competitions.

Conclusion

The grant-writing group at the University of Windsor integrated several strategies perceived by Porter (2011b) to encourage more and better grant proposals. These included offering "homegrown" workshops that were ongoing rather than occasional, sharing successful proposals, coaching and editing, bringing together emerging researchers with established ones, and placing participants in reviewers' shoes. These strategies were combined in a series of monthly sessions that required participants to write each section of a grant proposal and share it with others for feedback: project goals and objectives; significance, impact, and outcomes of the proposed project; theory; methodology; student training plans, knowledge mobilization/translation plans; and budgets. Participants perceived this approach to work well; it seemed to provide useful feedback and examples, and develop a sense of accountability and community. However, did the grant-writing group result in more and better grant proposals at the University of Windsor? In terms of encouraging more proposals, the group nearly doubled its productivity, moving from 9 applications in the granting period immediately prior to the group to 16 applications in the period during and afterward. The increase was primarily among the 10 emerging and alternative academic researchers with submissions of established researchers already high (average of 2 per cycle) prior to the grant writing group. In terms of producing better applications, the group approached the level of performance of the general university population. This is noteworthy considering that 10 of the 14 group members were new or less experienced with grant writing, with 9 of them submitting funding proposals. Of greatest importance is that the group experienced improvement in its own success rates. Moreover, the group seemed more effective in helping emerging researchers and alternative academics develop competitive proposals than it was in helping those mid to late career who were more experienced in writing for those competitions.

While we have been able to document successes in the greater number of submitted applications and successes as well in the positive feedback from participants, it is important to recognize that participants were a small, self-selected group of researchers. They had chosen to allocate a considerable amount of time to improve their grant-writing skills. Thus, the successes likely reflect the characteristics and commitment of the participants as much as the experience of participating in the group. That being said, grant applications themselves are submitted by a select group of researchers who choose to commit time to their preparation and to conducting funded research and the results of participation in the grant-writing group at the University of Windsor were consistent with those reported in the wider literature.

Authors' Notes

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Dr. Natasha G. Wiebe
Research Coordinator – Social Sciences, Humanities, & Health
Office of Research & Innovation Services, University of Windsor
401 Sunset Avenue
Windsor, Ontario, N9B 3P4, Canada
(519) 253-3000 x3953
nwiebe@uwindsor.ca

Dr. Eleanor Maticka-Tyndale
Distinguished University Professor
Department of Sociology, Anthropology and Criminology, University of Windsor
401 Sunset Avenue
Windsor, Ontario, N9B 3P4, Canada
(519) 253-3000 x2034
maticka@uwindsor.ca

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Appendix 1

Evaluation of Grant Writing Group

Thank you for agreeing to complete this evaluation of the Grant Writing Group. We welcome your responses and appreciate equally those that are positive and those that provide critical commentary.

Using the scale provided, please rate how helpful each of the following components of the Grant Writing Group was for you.

	didn't work at all	mostly didn't work	both worked & didn't work	mostly worked	worked extremely well	not appli-cable
1. The format: Beginning each session with work-in-progress groups, & ending with a mini-lecture & homework assignment.	☐	☐	☐	☐	☐	☐
2. The homework assignments.	☐	☐	☐	☐	☐	☐
3. The amount of time for peer feedback.	☐	☐	☐	☐	☐	☐
4. Suggestions for your writing from your work-in-progress group.	☐	☐	☐	☐	☐	☐
5. The facilitators visiting the work-in-progress groups.	☐	☐	☐	☐	☐	☐
6. Sharing your writing with a facilitator outside of the group.	☐	☐	☐	☐	☐	☐

7. Do you have any comments or suggestions related to the format of the groups?

Please rate how well each of the following worked for you on the scale provided.

	didn't work at all	mostly didn't work	both worked & didn't work	mostly worked	worked extreme ly well	not applicable
8. Meeting one Friday each month.	☐	☐	☐	☐	☐	☐
9. The 10 am start time.	☐	☐	☐	☐	☐	☐

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	didn't work at all	mostly didn't work	both worked & didn't work	mostly worked	worked extremely well	not applicable
10. The 12 pm end time.	☐	☐	☐	☐	☐	☐
11. The 2-hr duration of each session.	☐	☐	☐	☐	☐	☐
12. Starting the group in November and ending in June.	☐	☐	☐	☐	☐	☐
13. The August follow-up session.	☐	☐	☐	☐	☐	☐
14. The EPICentre workshop room.	☐	☐	☐	☐	☐	☐
15. The refreshments.	☐	☐	☐	☐	☐	☐

16. Do you have any comments or suggestions about the scheduling or administration of the group?

Please rate how often each of the following experiences was true for you from 1 for never to 5 for always (i.e., every time the group met):

	1 never	2	3 ½ & ½	4	5 always
17. I did not feel comfortable sharing my writing.	☐	☐	☐	☐	☐
18. I felt comfortable making critiques of the work of others.	☐	☐	☐	☐	☐
19. I felt safe receiving critiques from others.	☐	☐	☐	☐	☐
20. The work-in-progress groups did not help to strengthen my writing.	☐	☐	☐	☐	☐
21. I had difficulty understanding what I was supposed to do.	☐	☐	☐	☐	☐
22. We had conversations about non-grant related issues in my group (e.g., family, publishing, tenure process, teaching).	☐	☐	☐	☐	☐
23. I felt a responsibility to do my homework because I was presenting it to my group.	☐	☐	☐	☐	☐
24. I felt a responsibility to attend the group even when I wasn't able to do my homework.	☐	☐	☐	☐	☐

The next questions ask about skills that may have been strengthened as a result of participating in the Grant Writing Group.

I have significantly strengthened my skill in writing:

	yes	no	not sure	not applicable
25. for people outside my field of research	☐	☐	☐	☐
26. project goals/objectives	☐	☐	☐	☐
27. statements of significance	☐	☐	☐	☐
28. outcomes	☐	☐	☐	☐
29. theoretical frameworks	☐	☐	☐	☐
30. methodology sections	☐	☐	☐	☐
31. student training plans	☐	☐	☐	☐
32. knowledge mobilization/translation plan	☐	☐	☐	☐
33. budget justifications	☐	☐	☐	☐
34. an entire grant proposal	☐	☐	☐	☐

The next questions are about what might have happened as a result of participating in the Grant Writing Group. Please answer each as yes/no/not sure.

	yes	no	not sure
35. I have adopted some positive new writing habits.	☐	☐	☐
36. I feel more confident about applying for a grant.	☐	☐	☐
37. The group meetings and assignments have made developing a grant proposal more manageable.	☐	☐	☐
38. I am better prepared to offer other writers constructive, meaningful feedback on their grant proposals.	☐	☐	☐
39. Since participating in the Grant Writing Group I am more likely to begin drafting a grant proposal at least 6 months in advance of the deadline.	☐	☐	☐
40. Attending the grant writing group helped me develop at least one grant proposal that I submitted, or will submit, between January 2015 and April 2016.	☐	☐	☐
41. I would recommend the grant-writing group to others.	☐	☐	☐
42 I would participate in the Grant Writing Group if it was offered again.			
43. I anticipate staying in touch with at least one person that I got to know through the grant-writing group (other than Natasha and Eleanor).	☐	☐	☐

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If you anticipate staying in touch with a group member, please explain the nature of this anticipated ongoing contact (e.g., social, sharing writing, collaborating on a project).

44. What was most effective about the Grant Writing Group?

45. What was least effective about the Grant Writing Group?

46. Do you have any further suggestions or comments about how to improve the Grant Writing Group.

My responses on this survey may be used in writing the proposed publication.

☐ Yes ☐ No

Thank you for sharing your views and experiences with us.

Eleanor and Natasha

Allocation of R&D Equipment Expenditure Based on Organisation Discipline Profiles

Xanthe E. Wells
CSIRO

Nigel Foster
CSIRO

Adam Finch
CSIRO

Ian Elsum
Australian National University

Abstract: *Sufficient and state-of-the-art research equipment is one component required to maintain the research competitiveness of a R&D organisation. This paper describes an approach to inform more optimal allocation of equipment expenditure levels in a large and diverse R&D organisation, such as CSIRO. CSIRO is Australia's national science agency, is comprised of individual research units and conducts R&D across many disciplines. CSIRO's research equipment expenditure allocations have been to some extent based on both previous years' expenditures and current operating performance. In an effort to refine this process, a method was developed to consider the difference in expenditure profiles across research areas and calculate a benchmark (or expected level) for research units within CSIRO. The approach also allowed CSIRO to compare its actual equipment expenditure levels to benchmark (or expected) levels derived from expenditure data from US academic institutions. This comparison found that CSIRO's overall level of expenditure was below the benchmark levels and assisted in guiding the allocation of available funds more fairly across research units with different equipment needs.*

Several datasets were used for this analysis. R&D equipment expenditure patterns across disciplines are available for USA academic institutions and the differences in levels between disciplines was calculated. For example, in the Biological Sciences equipment expenditure is 3% of total R&D expenditure, whereas in Physics it is 3-fold greater. Using research publication subject classifications, discipline profiles were constructed for the entire CSIRO and each of its units. Publication subject categories were also mapped to the research fields used by the USA source. These datasets were combined to determine an overall benchmark value for CSIRO and each unit. The value varied by a factor of 2.2 fold across individual CSIRO units. Actual equipment expenditure for CSIRO was determined using internal finance records. This was compared to the benchmark levels and some units were below the calculated benchmark values and a few were close to or above.

The results of this study were considered by CSIRO managers when deciding equipment expenditure allocations and the implications of the findings for the organisation are discussed. Furthermore, it was found that there are very few studies on research equipment expenditure readily available and it is hoped that this study will encourage further discussion and research on this topic.

Keywords: *Research and development expenditures, laboratory equipment, research equipment, benchmarking, organisation, management*

Problem Statement

Methods to ensure capital resources are optimally allocated are of interest to Research and Development (R&D) organisations. In large organisations that are scientifically diverse, resource allocation is further complicated because there are differences in capital resource requirements between science areas. Allocation approaches used by institutions are often limited because they are largely retrospective and are based on current operating performance and/or what was allocated in previous years. In addition they do not examine trends in expenditure levels across different disciplines.

Funding, buildings, researchers and support staff, equipment, consumables and operating items are examples of R&D inputs and these inputs are suitable for benchmarking against other organisations. Research equipment expenditures are studied in this paper as they are more suited to benchmarking than some other inputs because similar items are purchased by research organisations worldwide and the equipment market is international (Georghiou, Halfpenny, and Flanagan 2001). In addition, laboratory equipment expenditure levels across different research areas are available for academic institutions in the USA from the National Science Board (2012, 2014). Examination of these data sets shows that expenditure levels differ between disciplines. For example, in the Biological Sciences equipment expenditure is 3% of total R&D expenditure, whereas in Physics it is 3-fold higher. Georghiou *et al* (2001) also highlights that different science areas will have different levels of infrastructure, including equipment, and labour for optimal outputs.

Georghiou and Halfpenny (1996) noted that despite equipment being a critical component to research progress, there is little information available on how to fund and manage it. We have also noted that there is very little information available on this topic. This study describes an approach to allow more optimal allocation of research equipment and is useful to large diverse organisations because it considers the equipment needs across different disciplines. It is based on benchmarking our organisation, CSIRO, against US academic institutions and is the foundation of the allocation process described and discussed.

Observations

a) R&D Expenditure Levels

R&D expenditure levels are considered to be indicative of innovative capacity because technological progress is dependent upon R&D effort. Expenditure levels are widely reported as a science and technology indicator and a common example is a country's gross domestic expenditures on R&D as a percentage of total gross domestic product. This is considered to be an indicator of a country's degree of R&D intensity and is often used as a summary statistic for international comparisons.

There are several types of input required for successful R&D outputs and outcomes and these include funding, buildings, researchers and support staff, equipment, consumables and operating items. The allocation of these resources at optimal levels, particularly capital resources, is obviously crucial to R&D organisations. The allocation process should ideally consider the needs of different organisational units and consider future requirements which may not necessarily reflect those of the past. The extent of change within the different units may also be dissimilar. Resource allocations should ideally anticipate these changes to some degree or at the very least reflect them as they occur.

Resource allocation in large diversified companies and R&D organisations is often based on current operating performance and/or allocations in previous years (Bower, 1986; Scholefield, 1994). Allocating resources for research equipment using these approaches is not optimal. Ideally, resources would be allocated based on the potential for creating value in the future rather than past or current needs. This, however, can be difficult to assess and requires a good understanding of both the relative potential for value creation across all application areas and the organisation's competitive position in each area, as well as anticipating future changes in requirements.

The study outlined in this paper describes an alternative approach to research equipment expenditure allocations. It describes a method that is applicable to diverse R&D organisations that span many disciplines and application areas. Levels of equipment expenditure in other organisations are also examined as they provide a competitive benchmark for comparison. Whilst the method does not consider the future potential for creating value and anticipating future needs, it does take into account differences in the types and equipment requirements across an organisation.

b) R&D Equipment Expenditures across Disciplines

The availability of current and sufficient equipment is a key component to a successful R&D organisation. Current and state-of-the-art equipment is necessary to maintain competitiveness and to attract high calibre researchers into the organisation. The relative importance of R&D equipment as an input is highlighted in the recommendations for external peer review of research organisations. The National Research Council (2012) recommends that equipment and facilities be considered as part of an assessment of ongoing research, together with evaluating the technical projects and the quality of research staff and management.

Equipment is more suited to benchmarking than some other R&D inputs because similar items are purchased by research organisations worldwide and the equipment market is international (Georghiou, Halfpenny, and Flanagan 2001). Collins, Couper and Record (1990) examined research expenditure in UK institutions across three sectors – industry, research council institutes and higher education institutions. Four disciplines were studied – biochemistry/pharmacology, chemistry, electrical engineering and electronics, and plant sciences. Whilst R&D equipment was not specifically examined, expenditure per researcher on non-pay items, including equipment, was measured. Overheads were excluded from this category. In universities, expenditure on non-pay items was the same for the three science disciplines and 2.6-fold higher for electrical engineering and electronics. Industry non-pay item expenditure levels on biochemistry/pharmacology were 3.2 times greater than electrical engineering and electronics levels. This study highlighted that R&D expenditure on non-pay items, including equipment, is dependent on the field of research and the sector in which the research is being conducted. Other studies in the open literature on equipment management, including expenditures by research field, are scarce.

Comprehensive R&D equipment expenditure data by research field is readily available from the National Science Foundation (NSF), which conducts an annual survey of US academic institutions on R&D funding sources and expenditures. Aggregated results from this survey are summarised in the Science and Engineering Indicators (2012, 2014) and provides a high level analysis of equipment expenditure trends in the US. The data behind this analysis is publically available making it possible to analyse equipment expenditure as a proportion of total R&D expenditure by research field. This enables an organisation or country to apply its research profile according to research field and compare itself to expenditure levels in US academic institutions. This comparison was undertaken for our organisation, CSIRO, to provide a greater appreciation of its current equipment situation and needs.

c) CSIRO and its Research Equipment Funding Allocations

CSIRO (Commonwealth Scientific and Industrial Research Organisation), is Australia's national science agency and is one of the world's largest and most diverse Research and Development (R&D) organisations. It employs approximately 5,300 people and has an annual budget of AUD1.2 billion. CSIRO conducts research in a wide range of disciplines within the following science and engineering areas – Energy; Environment; Manufacturing, Materials and Mining; Information Sciences; Food, Health and Life Sciences Industries. Its research results are used in a wide range of market sectors, including food and agribusiness, energy sector (solar, oil and gas), mining equipment technology and services, advanced manufacturing and medical devices, and materials. In 2012-13, CSIRO was broadly organised into 5 Groups and its constituent 12 Divisions are allocated to one of these.

CSIRO's annual capital budgeting process, which includes allocations for research equipment, is run centrally in two stages. Firstly a decision on the total amount for research equipment for the whole organisation is made; followed by decisions on the allocation for each Division. Decision-making is a collective process involving the heads of the 5 Groups and the corporate executive responsible for science strategy. The heads of the 5 Groups know their Divisions within their area

of responsibility but they have much less knowledge of Divisions in other Groups.

This capital budgeting process shares a number of features with resource allocation in large diversified companies, with similar tendencies to allocate resources based on current operating performance and/or allocations in previous years (Bower, 1986; Scholefield, 1994). As discussed above, allocating resources for research equipment based on this approach is not optimum.

Evaluation and Analysis of Concept

a) Calculation of R&D Equipment Expenditure Benchmark Values by Research Field

Table 1 shows the research equipment expenditures by research fields in US academic institutions over a five-year time period. These results were calculated from the National Science Foundation (NSF) survey described in the previous section, which provides aggregated data for R&D equipment expenditure and total R&D expenditure by research field. This allows the calculation of the proportion of expenditure on R&D equipment by research field, as well as an overall dollar value. Fields in the Physical Sciences have the highest level of equipment expenditure and overall it is 3-fold higher than equipment expenditure in the Life Sciences. Equipment expenditure levels are lowest in the Social Sciences.

Table 1. Average Expenditures of Funds for Research Equipment at US Academic Institutions as Percentage of Total Academic R&D Expenditure by Field 2005-2009..

NSF Fields of Science And Engineering		US Academic Institutions Research Equipment Expenditures as % of Total R&D Expenditure, 2005-09 (inclusive)
All Fields		**3.8**
Computer Science		**5.4**
Environmental Science		**4.8**
	Atmospheric	6.0
	Earth Sciences	4.3
	Oceanography	5.6
	Environ. Science NEC	2.7
Life Sciences		**2.6**
	Agricultural Sciences	2.8
	Biological Sciences	3.2
	Medical Sciences (Including Vet. Med.)	2.2
	Life Sciences NEC	3.4
Mathematical Sciences		**1.6**
Physical Sciences		**8.2**
	Astronomy	5.2
	Chemistry	8.1
	Physics	8.9
	Physical Sciences NEC	9.1
Psychology		**1.9**
Social Sciences		**1.0**
	Economics	0.4
	Political Science	0.4
	Sociology	0.8
	Social Sciences NEC	1.7
Science NEC		**7.6**
Engineering		**5.8**
	Aeronautical/Astronomical	5.1
	Bioengineering/Biomedical	5.2
	Chemical	6.6
	Civil	3.4
	Electrical	5.5
	Mechanical	7.0
	Metallurgical/Materials	8.3
	Engineering NEC	5.8

NEC = Not Elsewhere Classified
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditur
Universities and Colleges: FY 2009.
Appendix table 5-6. R&D expenditures at academic institutions, by S&E field: Selected years, 1975–2009
Appendix table 5-14 Current expenditures for research equipment at academic institutions, by S&E field: Selected years, 1985–2009

The survey includes expenditure for indirect costs. The National Science Foundation describes research equipment as 'movable items necessary for the conduct of organised research projects'. It is also noted that 'generally, university equipment that cost less than $5,000 would be classified under the cost category of 'supplies'. However, private communication with the National Science Foundation indicates that institutions set their own thresholds and this may be as low as $1,000 in some institutions. The overall value of equipment purchased below these thresholds is not known and it is therefore not possible to account for such equipment in this analysis. The survey results do not include data on research facilities and cyberinfrastructure as this information is collected in a separate mechanism, the Survey of Science and Engineering Research Facilities. In this survey, facilities are assessed by using metrics on research space, repairs and renovation; and cyberinfrastructure is assessed by networking, high-performance computing and data storage indicators.

b) CSIRO's Research Profile

CSIRO is a large multidisciplinary national science agency with total R&D expenditure of approximately AUD1.2 billion. During 2008-12, CSIRO produced 12,360 research publications that were captured in the Thomson-Reuters Web of Science (WoS) publication data base and the overwhelming majority of these (10,951, 89%) were journal articles. In addition, there were 751 conference proceedings papers and 657 reviews. The Web of Science database classifies research journals into approximately 250 subjects and the diversity of CSIRO's research profile is evident by its publication profile according to Web of Science subjects. The two largest subjects for CSIRO are Environmental Sciences and Ecology, between them accounting for 14% of publications. Though slightly smaller in output, CSIRO also focuses heavily on the subjects Materials Science (Multidisciplinary), Plant Sciences and Astronomy & Astrophysics, each of which represent around 6% of CSIRO's output. Overall, there are over 80 subjects in which CSIRO produced 40 or more publications during this 5-year period.

In 2013, CSIRO was comprised of 12 Divisions, each with a unique publication output profile. WoS subject area profiles have also been generated for each of these and Table 2 lists the largest subject areas for each Division. The multidisciplinary research profile of CSIRO is evident from this Table.

The next step in this study was to compare levels of equipment expenditure in CSIRO to levels in US academic institutions and to achieve this Web of Science subjects were mapped to the research fields used by the NSF. The resulting translation table is shown in the Appendix. A research profile for CSIRO and individual Divisions by research fields used by the NSF was then produced and the profile for CSIRO is shown in Figure 1. There are six fields each comprising more than 5% of CSIRO output. The largest is Biological Sciences, followed by Environmental Sciences, Earth Sciences, Chemistry, Physics and, lastly, Metallurgical and Materials Engineering.

Table 2. CSIRO Divisions and the Main Web of Science Subjects for their Research Publications produced between 2008-12.

CSIRO Division	Main Web of Sciences Research Publications Classifications
CSIRO Animal, Food and Health Sciences	Food Science & Technology
	Veterinary Sciences
	Biotechnology & Applied Microbiology
	Nutrition & Dietetics
	Agriculture, Dairy & Animal Science
	Genetics & Heredity
	Virology
	Microbiology
CSIRO Astronomy and Space Science	Astronomy & Astrophysics
CSIRO Earth Science and Resource Engineering	Geosciences, Multidisciplinary
	Geochemistry & Geophysics
	Energy & Fuels
	Engineering, Chemical
	Materials Science, Multidisciplinary
CSIRO Ecosystems Science	Ecology
	Environmental Sciences
	Entomology
	Zoology
	Forestry
	Biodiversity Conservation
	Agriculture, Multidisciplinary
	Plant Sciences
	Environmental Studies
CSIRO Energy Technology	Energy & Fuels
	Chemistry, Physical
	Engineering, Chemical
	Electrochemistry
	Materials Science, Multidisciplinary
CSIRO Information and Communication Technology	Engineering, Electrical & Electronic
	Telecommunications
	Computer Science, Information Systems
	Computer Science, Theory & Methods
	Computer Science, Artificial Intelligence
CSIRO Land and Water	Environmental Sciences
	Water Resources
	Geosciences, Multidisciplinary
	Soil Science
	Engineering, Environmental
	Engineering, Civil
	Agronomy
CSIRO Marine and Atmospheric Research	Oceanography
	Marine & Freshwater Biology
	Meteorology & Atmospheric Sciences
	Fisheries
	Environmental Sciences
	Ecology
	Geosciences, Multidisciplinary
CSIRO Materials Science and Engineering	Materials Science, Multidisciplinary
	Physics, Applied
	Chemistry, Physical
	Chemistry, Multidisciplinary
	Polymer Science
	Nanoscience & Nanotechnology
	Physics, Condensed Matter
	Biochemistry & Molecular Biology
CSIRO Mathematical and Information Sciences	Statistics & Probability
	Engineering, Chemical
	Mathematics, Interdisciplinary Applications
CSIRO Plant Industry	Plant Sciences
	Agronomy
	Genetics & Heredity
	Agriculture, Multidisciplinary
	Horticulture
	Biochemistry & Molecular Biology
	Biotechnology & Applied Microbiology
CSIRO Process Science and Engineering	Metallurgy & Metallurgical Engineering
	Materials Science, Multidisciplinary
	Engineering, Chemical
	Mineralogy
	Mining & Mineral Processing

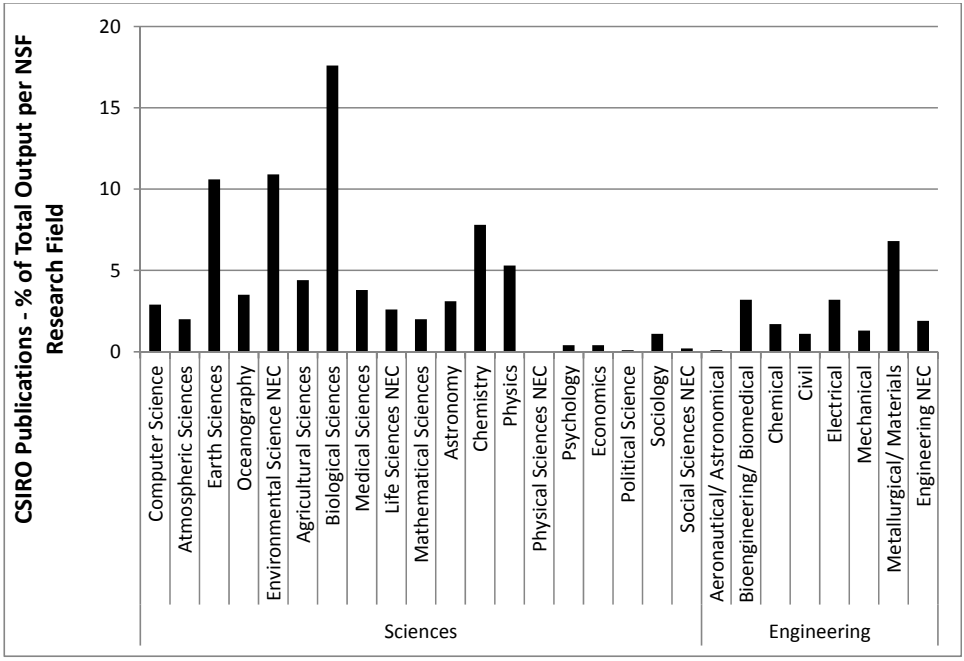

Figure 1. CSIRO Publication Output by National Science Foundation Science and Engineering Fields, 2008-12.

c) CSIRO's R&D Equipment Expenditure and Comparison to US Academic Institutions

The following steps were taken to calculate benchmark values for CSIRO and its Divisions and are summarised in Figure 2. The research profile for each entity based on research publications was determined as described in section 3 above. The benchmark equipment expenditure percentages for each contributing research field (see Table 1) was then multiplied by the percentage of publications in the research field and expressed as a percentage. These values were then totalled to provide an overall benchmark value for CSIRO and each Divisions and this was then compared to the actual expenditure as a percentage of total R&D expenditure calculated (Table 3). CSIRO's average actual expenditure for a four-year period was also calculated from internal finance records.

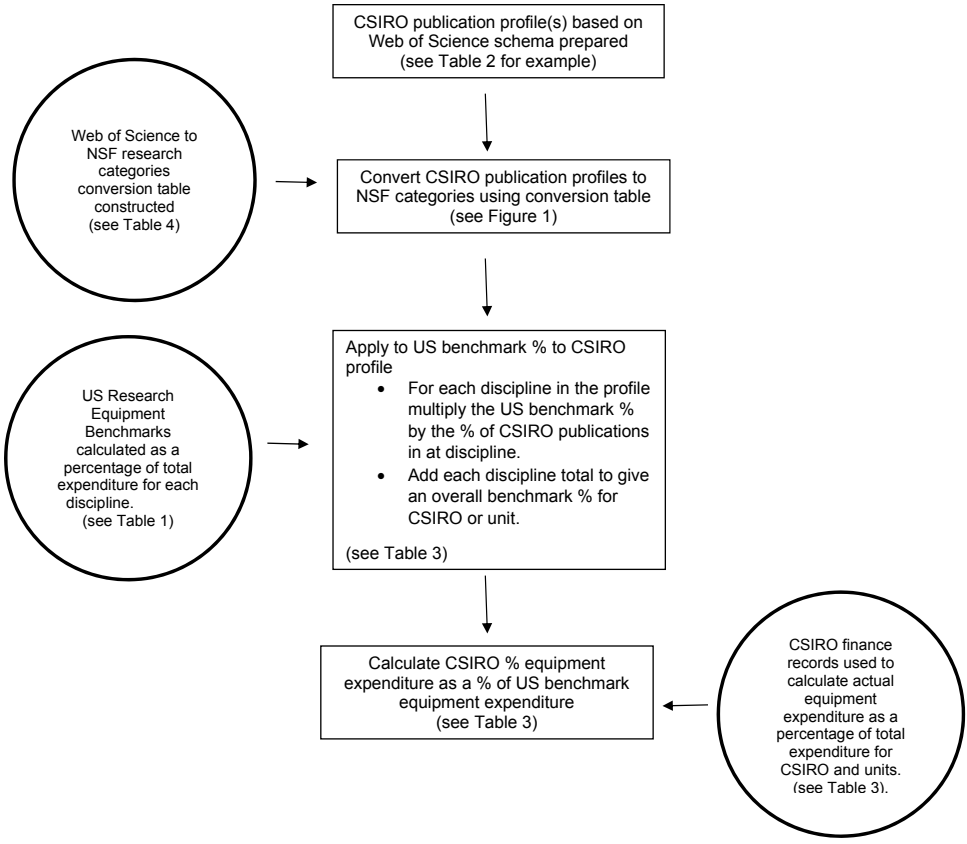

Figure 2. Flow Diagram of Benchmark and Actual Equipment Expenditures. NSF = National Science Foundation

CSIRO defines its assets as items over AUD3,000 (approximately USD2,250) with an enduring value in use. They are categorised into several classes including Land, Buildings, Vehicles, Office, Scientific and IT. Only items in the Scientific category were included in this study. The AUD3,000 threshold value is relatively high in the Australian public sector, however, it has been nominally constant for at least the last 15 years and therefore has decreased in real terms. These values do not include major research facilities such as the Australian Square Kilometre Array Pathfinder, although some smaller items associated with this may be included in R&D equipment expenditure. CSIRO also includes overheads as part of its overall R&D expenditure, as does the NSF.

In 2012-13 financial year, CSIRO's total R&D expenditure was AUD1.16 billion. At the whole-of-organisation level, actual R&D equipment expenditure was one-third lower than the calculated benchmark value. Whilst this was recognised as a serious issue, overall budget constraints did not allow the organisation to meet the benchmark expenditure level. One Division is above the

benchmark value and another is close to the value. Of the remaining Divisions, all were 85% or lower, with 3 Divisions being less than half of its benchmark level.

Table 3. CSIRO and its Divisions - Total R&D Expenditure, Equipment Benchmark Percentage and Actual Equipment Expenditure Percentage.

CSIRO Unit	FY 2012-13 Total R&D Expenditure (AUD millions)	4-year average (2010 to 2013, inclusive) Equipment Benchmark (% of expenditure)	Equipment Actual (% of expenditure)	CSIRO Expenditure as a % of Benchmark Expenditure
Whole of organisation	1162.5	4.8	3.4	67
Animal, Food and Health Sciences	154	3.6	2.6	72
Astronomy and Space Science	41	5.3	4.5	85
Earth Science and Resource Engineering	94	5.6	3.2	57
Ecosystems Science	115	3.3	1.5	46
Energy Technology	48.5	7	8.3	119
Information and Communication Technology	71	5.3	1.5	28
Land and Water	94	3.8	2.2	58
Marine and Atmospheric Research	127	4.4	2.8	64
Materials Science and Engineering	173	7.3	4.9	67
Mathematical and Information Sciences	47	4.3	0.8	19
Plant Industry	125	3.5	3.3	94
Process Science and Engineering	73	6.8	3.8	56

d) Equipment Expenditure Trends in US Academic Institutions

The benchmark data source for this study is from the NSF which collects data from US academic institutions. It was chosen because it is readily available and covers many institutions over a long time period. Data is also classified on a research field basis and no other data set as complete as this has been identified. This is the main reason why this dataset was chosen for this study. The US data set is comprehensive, covers a wide range of academic institutions and it is generally considered that US R&D is of good quality globally. In addition, the survey is updated every second year and this allows for ongoing evaluation.

The proportion of total R&D equipment expenditure in US academic institutions has declined from 4.1% in 2005 to 3.2% in 2012, whereas actual total expenditure has increased (Figure 3). The Science and Technology Indicators (2014) indicate that FY 2012 equipment expenditure 'fell to the lowest levels measured in constant dollars since FY 2001'. There is no information available to indicate whether or not these levels of equipment expenditure are adequate but it is likely that they are not in some US institutions, especially given the drastic downturn in the US economy following the Global Financial Crisis. Witonsky (2011) noted in a report covering all types of US laboratories, including academic, hospital and biotechnology laboratories, that the economic downturn had greater impact on equipment budgets than any other laboratory expenditure category. In addition, there may have been other external factors contributing to this decline.

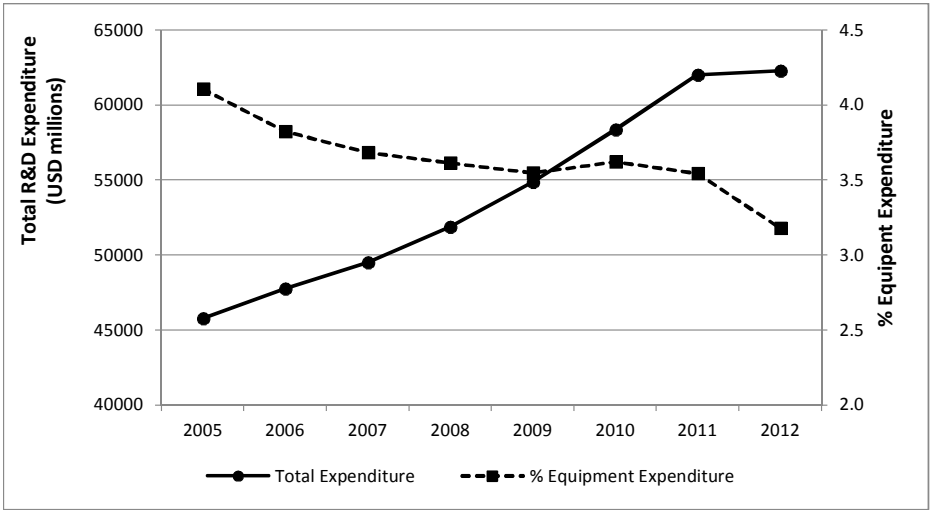

Figure 3. Trends in R&D Equipment and Total Expenditures in US Academic Institutions, 2005-12. DATA SOURCE: Science and Technology Indicators, National Science Board, 2014.

Reflect and Recommend Solutions

This paper explores a new approach to inform the allocation of R&D equipment expenditures and outlines the implications of the findings to our organisation, CSIRO. The method could also be applied to other large multidisciplinary organisations because it considers the variation in equipment needs across a range of disciplines.

There were several implications of this study to CSIRO. The study confirmed the anecdotal evidence that the organisation was spending less on its R&D equipment than the benchmark figure suggested to be optimal and provided an approximate quantification on the extent of this gap. It was not, however, possible to allocate additional funds to make up this short fall. The study also highlighted to the organisation the differences in capital intensity of different research fields and how this applied to the organisation. The process provided a clear and easily understood basis for allocations for R&D equipment. Consequently, the initial notional allocations, resulting from simply applying the 'algorithm' to each Division, were perceived as a fair and equitable starting point for making final allocations. Discussion among the decision-makers was then restricted to whether there were any exceptional circumstances that would warrant changing the allocations at the Group level. Generally there were not; the allocations at the Group level were accepted and then small adjustments were made within each Group to take account of the circumstances of each Division in that particular year, for example, the need to purchase an unusually expensive piece of equipment. More recently, the method has assisted managers to understand the equipment needs across the organisation following a significant restructure and continues to guide discussions on allocations.

The study used an organisational research profile based on the Web of Science publication classification but it could readily be replaced with other publication classification schemes or other parameters, such as financial or human resources data, provided it was allocated on a field of research basis. Not only was the approach applicable to an entire organisation, but it was possible to examine smaller parts of the organisation in more detail.

Whilst benchmarking CSIRO would ideally involve gathering data from peer national research agencies, this was not attempted. The benchmark data source for this study is from the NSF which collects data from US academic institutions. It was chosen because it is readily available and covers many institutions over a long time period. Data is also classified on a research field basis and no other data set as complete as this has been identified. This is the main reason why this dataset was chosen for this study. The US data set is comprehensive, covers a wide range of academic institutions and it is generally considered that US R&D is of good quality globally. In addition, the survey is updated every second year and this allows for ongoing evaluation. The Main Science and Technology Indicators (2014) from the OECD provides data on two capital expenditure categories – 'land and buildings' and 'instruments and equipment' – by research sector for its member countries. This was also examined but not used because information on expenditure per research field is only provided for the combined capital expenditure categories and, therefore, is not at the required level of detail for the purposes of this study. Ideally it would be more optimal for CSIRO to benchmark against other government R&D organisations but this information is not available. In addition, CSIRO does have a reasonably high level of publication output and it is generally considered within the organisation that the publication research profile is a sound representation of its overall research profile.

It is important to note the approach described in this study should be used to provide guidance rather than absolute answers because of some limitations as outlined below.

1. The method uses a research publication output to define the research profile of the organisation. This would not be applicable to an organisation whose publication profile does not reasonably reflect its research areas. If this is the case, financial or human resources data would be a better choice. This could include private R&D companies or applied R&D organisations that do not publish to the same extent as academic organisations.
2. It is likely that the levels of R&D equipment in US academic institutions are probably not optimal, especially in recent years, due economic conditions. This should be kept in mind if an organisation is using this approach to determine optimal R&D equipment expenditure levels.
3. The definition of 'R&D equipment' varies between organisations as well as within different parts of an organisation and it is not possible to readily account for this variation. At the lower end of the monetary scale, the threshold cost values of equipment and supplies varies between organisations. CSIRO classed equipment in this study as equipment assets valued at AUD3,000 (approximately USD2,250) and above. This was slight different to the US equipment data as this was collected from multiple institutions and the threshold varied from USD1,000 to 5,000. Both sources did not include major

research infrastructure. Geoghiou (2001) also highlights that there are 'methodological, conceptual and practical challenges involved in any attempt to systematically benchmark research equipment.'

4. The National Science Foundation data provides a level of R&D equipment expenditure for academic institutions. It is likely that this level would also apply to organisations for which producing new knowledge is important. This level, however, may not be appropriate for other types of institutions such as industrial ones.

A survey of UK universities (Georghiou and Halfpenny, 1996) showed in 1994/95 they spent 13% of their research income on research equipment. This is higher than levels reported in US academic institutions and there are likely to be differences in survey methodologies, as well as different funding and reporting approaches. The higher UK level does not appear to be due to adequate or more equipment being available in UK universities because 79% of UK university departments indicated that they were unable to perform critical experiments due to inadequate equipment. It was also found that 38% of researchers surveyed indicated that their equipment was older than their international peers and it had a higher cost for repairs and maintenance. In addition, it was found that the research equipment required to remain competitive is becoming more expensive. Values of these increased costs were provided as follows:

1. Replacement of equipment with equivalent functionality averaged 1.37 times the original cost of current equipment.
2. The cost of new equipment with a level of functionality similar to the current state of the field as the original item was when it was purchased averaged 1.56 times the original cost.
3. Replacement with state-of-the-art equipment averaged 2.67 times the original cost.

Whilst this report was produced some time ago and it is likely that the actual increases reported may have changed; it highlights that for an organisation to maintain its relative competiveness it needs allow additional funds to replace out-of-date equipment.

Our study does not consider the age and condition current R&D equipment and an understanding of this in CSIRO would require further investigation. If, however, an organisation is not sufficiently spending on its R&D equipment, it is very likely that it is not replacing equipment as it ages. It is therefore likely to have a significant amount of out of date equipment, as well as equipment requiring repair, in its laboratories.

R&D equipment undoubtedly has a key role in producing research outputs. Whether or not the equipment is being used optimally in terms of output is difficult to assess between types of institutions and different research fields. A broad assumption would be that academic institutions aim to produce more publications in research journals whereas industrial institutions would produce more intellectual property. There are also differences in publication and intellectual property output levels between research fields. CSIRO researchers in the environmental and space sciences produce relatively high levels of publications and low levels of patents, whereas its researchers in engineering fields tended to have higher patenting rates and biotechnology-related CSIRO researchers produced reasonable amounts of both publications and patents. To determine benchmark levels of output relative to equipment expenditure would therefore need to

take into account the research field and whether or not the institute has an industry or academic focus. Georghiou, Halfpenny, and Flanagan (2001) also highlights that different areas of science will have different levels of infrastructure, including equipment, and labour for optimal outputs.

Conclusions

This study describes an alternative approach to inform the more optimal allocation of R&D equipment resources because it considers the variation in equipment needs across different disciplines. The approach would be useful to large diverse organisations, such as CSIRO, that span many disciplines and application areas. Levels of equipment expenditure in other organisations are also examined because it provides a competitive benchmark for comparison.

The study provided CSIRO an assessment of the level of equipment expenditure at the organisational level compared to other institutions. It also identified units within CSIRO with the lowest levels of equipment expenditure. This information is useful in both strategic and operational contexts.

This work could be further expanded by investigating the age and condition of current equipment and quantifying this at the organisational level, as well as further understanding optimal levels of equipment in relation to research outputs, such as intellectual property and publications. It would also be more relevant to benchmark CSIRO against national research agency peers rather than academic institutions. The study also noted how little information on R&D equipment management and expenditure is available in the literature and it is hope that this work will stimulate further discussion on the topic.

Xanthe E. Wells
Executive Manager
CSIRO
5 Julius Ave., North Ryde, NSW, 2113, Australia
+61 2 9490 8194
xanthe.wells@csiro.au

Nigel Foster
Project Manager
CSIRO
5 Julius Ave., North Ryde, NSW, 2113, Australia
+61 2 9490 8366
nigel.foster@csiro.au

Adam Finch
Analyst
CSIRO
Private Mail Bag 2, Glen Osmond, SA, 5064, Australia
+61 8 8273 8105
adam.finch@csiro.au

Ian Elsum
Formerly at CSIRO
Currently Visiting Fellow
Research School of Management
The Australian National University
Canberra, ACT, 0200, Australia
ian.elsum@anu.edu.au

Correspondence concerning this article should be addressed to Xanthe Wells, Executive Manager, CSIRO, 5 Julius Ave., North Ryde, NSW, 2113, Australia, xanthe.wells@csiro.au

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Appendix:

Table 4.
Translation of Web of Science Subjects to NSF Science and Engineering Fields.

NSF Fields of Science And Engineering	Web of Science Subjects
Computer Science	Computer Science Artificial Intelligence, Computer Science Cybernetics, Computer Science Hardware Architecture, Computer Science Information Systems, Computer Science Interdisciplinary Applications, Computer Science Software Engineering, Computer Science Theory Methods
Environmental Science	
Atmospheric	Meteorology Atmospheric Sciences
Earth Sciences	Engineering Geological, Geochemistry Geophysics, Geography, Geography Physical, Geology, Geosciences Multidisciplinary, Limnology, Mineralogy, Paleontology, Soil Science, Water Resources
Environ. Science NEC	Ecology, Environmental Sciences, Remote Sensing
Life Sciences	
Agricultural Sciences	Agriculture Multidisciplinary, Agriculture Dairy Animal Science, Agronomy, Food Science Technology, Horticulture
Biological Sciences	Anatomy Morphology, Biochemical Research Methods, Biochemistry Molecular Biology, Biology, Biology, Biotechnology Applied Microbiology, Cell Biology, Developmental Biology, Entomology, Evolutionary Biology, Forestry, Genetics Heredity, Parasitology, Physiology, Plant Sciences, Marine Freshwater Fisheries, Microbiology, Microscopy, Mycology, Neuroimaging, Reproductive Biology, Ornithology, Veterinary Sciences, Virology, Zoology
Medical Sciences, including Vet. Med.	Allergy, Andrology, Anesthesiology, Audiology Speech Language Pathology, Cardiac Cardiovascular Systems, Chemistry Medicinal, Clinical Neurology, Critical Care Medicine, Dentistry Oral Surgery Medicine, Dermatology, Emergency Medicine, Endocrinology Metabolism, Gastroenterology Hepatology, Geriatrics Gerontology, Gerontology, Health Care Sciences Services, Hematology, Immunology, Infectious Diseases, Integrative Complementary Medicine, Medical Informatics, Medical Laboratory Technology, Medicine General Internal, Medicine Research Experimental, Neurosciences, Nursing, Nutrition Dietetics, Obstetrics Gynecology, Oncology, Ophthalmology, Otorhinolaryngology, Pathology, Pediatrics, Peripheral Vascular Disease, Pharmacology Pharmacy, Primary Health Care, Public Environmental Occupational Health, Radiology Nuclear Medicine Medical Imaging, Rehabilitation, Respiratory System, Rheumatology, Sport Sciences, Surgery, Toxicology, Transplantation, Tropical Medicine, Urology Nephrology
Life Sciences NEC	Biodiversity Conservation
Mathematical Sciences	Mathematical Computational Biology, Mathematics, Mathematics Applied, Mathematics Interdisciplinary Applications, Statistics Probability
Physical Sciences	
Astronomy	Astronomy Astrophysics
Chemistry	Chemistry Analytical, Chemistry Applied, Chemistry Inorganic Nuclear, Chemistry Multidisciplinary, Chemistry Organic, Chemistry Physical, Crystallography, Electrochemistry, Polymer Science
Physical Sciences NEC	Biophysics, Nanoscience Nanotechnology
Psychology	Behavioral Sciences, Psychiatry, Psychology, Psychology Applied, Psychology Biological, Psychology Clinical, Psychology Developmental, Psychology Experimental, Psychology Mathematical, Psychology Multidisciplinary, Psychology Social
Social Sciences	
Economics	Agricultural Economics Policy, Business, Business Finance, Economics
Political Science	History, History Philosophy Of Science, International Relations, Political Science
Sociology	Agricultural Economics Policy, Business, Business Finance, Economics, Ergonomics, Ethics, Family Studies, Law, Philosophy, Public Administration, Social Issues, Social Sciences Biomedical, Social Sciences Interdisciplinary, Social Sciences Mathematical Methods, Social Work, Sociology, Substance Abuse
Social Sciences NEC	Anthropology, Archaeology, Architecture, Art, Communication, Education Educational Research, Education Scientific Disciplines, Environmental Studies, Health Policy Services, Hospitality Leisure Sport Tourism, Humanities Multidisciplinary, Information Science Library Science, Language Linguistics, Linguistics, Literature British Isles, Transportation
Science NEC	Imaging Science Photographic Technology, Multidisciplinary Sciences
Engineering	
Aeronautical/ Astronomical	Engineering Aerospace
Bioengineering/ Biomedical	Cell Tissue Engineering, Engineering Biomedical, Materials Science Biomaterials
Chemical	Engineering Chemical
Civil	Engineering Civil
Electrical	Engineering Electrical Electronic, Telecommunications
Mechanical	Automation Control Systems, Engineering Mechanical, Mechanics, Robotics
Metallurgical/ Materials	Materials Science Ceramics, Materials Science Characterization, Testing, Materials Science Coatings Films, Materials Science Composites, Materials Science Multidisciplinary, Materials Science Paper Wood, Materials Science Textiles, Metallurgy Metallurgical Engineering, Mining Mineral Processing
Engineering NEC	Agricultural Engineering, Energy Fuels, Engineering Environmental, Engineering Industrial, Engineering Manufacturing, Engineering Marine, Engineering Multidisciplinary, Engineering Petroleum, Instruments Instrumentation

NEC = Not Elsewhere Classified

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