



# Report of the Research Task Force January 2016

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## I. Introduction to the Committee

The Research Task Force (TF) was established by the Senior Vice President of Research and Technology Transfer in May 2015 to examine the monetary investment the institution provides to the research enterprise. Each Dean appointed representatives from their College to ensure adequate representation throughout the academic disciplines. Tracy Camp and Tzahi Cath from College of Engineering and Computer Science (CECS), Paul Sava and Hossein Kazemi (Hossein removed himself from the committee) from the College of Earth Resources Science and Engineering (CERSE), and Ryan Richards and John Speer from the College of Applied Science and Engineering (CASE). The TF was facilitated by Bruce Honeyman and John Speer, Associate Vice Presidents of Research, and Lisa Kinzel, Director of Research Development, and met weekly through the summer and fall semesters with a deliverable of a written report of initiatives and recommendations to the Vice President of Research and Technology Transfer.

Throughout the summer the TF's charge evolved into not only addressing the monetary investment in research but also addressing research initiatives that were important to the faculty campus wide. The committee had two opportunities to seek input from faculty. The first instance was during the summer when each committee member was tasked with asking faculty in their colleges for input. Specifically, several faculty were asked "what do you need to grow your research enterprise (where you can define growth however you want)?" The second instance was at the Faculty Conference in August 2015 where the Task Force made a presentation during a break out session. All feedback was collated and extensively discussed among the committee members and was the basis for the initiatives that the committee inevitably chose to explore.

In December 2015 the TF presented their initiatives and recommendations to the President and his Executive Team, where he requested this group to continue their efforts in working through implementing some of these initiatives. In January 2016, the TF presented their findings to the Board of Trustees. The TF is meeting with the President in February 2016 for his direction on moving forward.

This report includes a detailed account of the initiatives along with recommendations on implementation.

## II. Charge to the committee

The Strategic Plan for Colorado School of Mines states: "Mines will be the premier institution, based on the impact of its graduates and research programs, in engineering and science relating to the earth, energy, and the environment." Fulfilling that aspiration will require significant growth in our research funding and a growing emphasis on high-impact research that addresses national and global grand challenges. To help Mines achieve that research goal, the Task Force was asked to address the following question

*What are the specific qualities defining a ‘premier institution’ in research, and how can Mines more effectively utilize its resources (capital and human) to achieve the ‘premier’ status?*

To evaluate this question the Task Force needed to: (1) assess the ways in which leading academic institutions utilize their resources; and (2) help provide faculty perspectives for guidance to the Office of the VPRTT on paths for moving forward. The goal is not simply to emulate other leading institutions but to define and foster our niche and uniqueness in the academic world to create the premier institution envisioned.

### III. Executive Summary

The research agenda here at Mines has real strengths and is productive, but has challenges that need to be addressed if we want to elevate this institution to the next level of recognition as a leading research university.

After several opportunities to hear the faculty’s thoughts on enhancing research at Mines, a handful of concerns rose to the top as priorities. It is apparent that we must enable faculty to get back to their core strengths in performing research and not be mired down in administrative details. The community must work to increase and improve our graduate student population and determine a way to recruit and retain these students. Faculty morale must be addressed with regard to equalizing the workload in departments and consistently mentoring our faculty to help ensure that they succeed. Our research infrastructure needs to be realigned to allow Mines to address big global challenges more effectively and efficiently.

This report is a written analysis of the five initiatives that the TF has chosen to pursue with insightful recommendations on how to move forward. While these initiatives were explored separately, there was much discussion amongst the TF as a whole. Each member weighed in on each initiative and is completely supportive of that initiative and the recommendations. The TF recognizes that implementing any of these initiatives will require support of the administration at all levels.

Although additional detail can be found in the individual sections, a summary of each initiative follows.

#### **Graduate Student Initiative**

Graduate Students and research go hand-in-hand. If Mines is going to succeed as a research university we need to improve the quality of our graduate students. The following lists the outcome of discussions with administrators and students on how to fulfill this initiative.

1. Assess graduate program ranking systems and how to maximize Mines standing.
2. Formalize, highlight, and advertise the Mines–NREL collaboration. Develop jointly funded graduate opportunities with NREL.

3. Work to improve campus life for graduate students. Assess the current housing situation with Mines Park (or other on-campus housing) and consider prioritizing first year graduate students and visiting scholars or reserving space for their presence.
4. Evaluate all graduate student funding. How can we fund prestigious fellowships and more competitive stipends? Determine if graduate studies are being funded at a level proportional to their numbers on campus (i.e., are we putting enough resources into graduate students; and has graduate student life grown as undergraduate student life grown?)
5. Increase recruiting efforts and funding for on-campus visits. Coordinate open houses. (A pilot program for some departments is in place by the Grad School for fall 2016 admissions)

### **Work Load Initiative**

Mines spends significant funds each year on research through 40% faculty “release” time. Is Mines being strategic with these expenditures? Also, unfair workload hurts faculty morale on campus and needs to be addressed. The following list outlines areas to address in order to continue to attract and retain the best and brightest faculty.

1. Mines administration should develop a new faculty workload model for Mines T/TT faculty. See A6 for the ASU model.
2. Mines should adopt a culture where teaching is valued. For example, Mines currently has a way for faculty to “buy out of teaching” (via research funds); we recommend that Mines provide a way for faculty to “buy out of research” (via increased teaching load).
3. All Mines T/TT faculty members should be required to create a Google Scholar profile. We recommend Google Scholar because this site is the easiest to maintain (i.e., the site updates automatically once the profile is created). In addition, all Mines research active faculty should have their own websites to further outreach the broader community and be a portal for recruiting graduate students.

### **Faculty Mentoring Initiative**

Individual and quality mentoring are key for faculty success. Discussions with faculty have determined that our mentoring is not consistent, and is nonexistent in some departments. Recommendations to improve faculty mentoring on campus are:

1. Mines should continue (and perhaps expand) the new faculty mentoring that occurs in August each year, such that research mentoring is a key aspect of this event.
2. Mines should host at least two mentoring events each semester where all faculty are invited to attend.
3. Mines should adopt university-wide guidelines that specify what departments should be doing for individual faculty mentoring.

### **Faculty Administrative Burden Initiative**

At the time of the initial TF discussions on faculty administrative burden, the two issues of greatest concern were the time to negotiate and finalize industry contracts and the lack of a simplified accounting system (“checkbook” accounting) for research projects. During the Task Force’s study period, a new hire was made in ORA to help address the contract negotiation issues. Because this change is recent, the additional resource hired may

alleviate the problems that exist. Additionally, the TF was told by ORA that their office was acquiring software to enable a “checkbook” like software for faculty to view and manage their research accounts. Although we are unaware of when this product will be live, we cannot make additional recommendations until we establish if this product improves the faculty accounting duties.

### **Interdisciplinary Research**

One of the most significant impediments to the development of a dynamic interdisciplinary culture at Mines is the fact that most faculty are simply unaware of the research conducted by fellow faculty/researchers outside their home units. To make it easier for faculty to identify and/or engage in collaborative research, the TF recommends:

1. Mines proceeds with annual or bi-annual faculty conferences dedicated exclusively to research communication, with particular focus on interdisciplinary science.
2. Mines significantly expands discretionary funding available to the VPRTT, Deans, and possibly DHDDs to stimulate interdisciplinary research across divisions under their supervision.
3. Mines proceeds with a detailed study of the mechanisms needed to set-up interdisciplinary research units on the model of the MIT MediaLab, but with focus on specific CSM strengths.

### **Grand Challenge Institutes**

An important external driver for this initiative is that many of the significant problems facing society (e.g., climate change, renewable energy, food production, access to safe water, aging infrastructure and national security) can only be addressed by integrated teams consisting of experts in different fields, rather than by isolated disciplinary teams. The TF, with support from Mines faculty, believes that restructuring our centers and establishing research institutes that are intrinsically interdisciplinary and mission-oriented will distinctly position Mines to successfully address these global challenges. These strategically important institutes will function more efficiently in space and resource-utilization, will facilitate interdisciplinary science and education, and most importantly will more efficiently utilize the scientific and engineering talent available at Mines.

## **IV. Initiatives**

### **a. Graduate Students**

Within the research enterprise, the people who are directly doing the research are highly influential on the quality of the research performed and the outcomes. Everyday researchers working on projects are making hypotheses, designing experiments, making observations, interpreting data, and making decisions that determine the research direction. Graduate students comprise the vast majority of researchers on campus and have a dramatic influence on the research success or lack thereof. Further, high quality graduate students are able to elevate all those around them while poor graduate students can sometimes bring down others. If we assume (as rough estimations) that each graduate

student costs somewhere between \$50k (for Mines supported) and \$80k (for external grants with overhead and fringe) per year, and that it will take most 5 years to finish, we are looking at a minimum investment of \$250k per graduate student.

Initial communications with faculty and breakout sessions almost unanimously put graduate student quality as a high priority for improving research. From the breakout sessions, a prioritization of suggestions to improve graduate students was discussed as well as development of new ideas. Suggestions from the breakout sessions included: graduate research fellowships, increased stipends, more recruiting efforts, graduate student housing, faster processing of applications, and on-campus childcare, to name a few. To assess and prioritize these for the university, Dr. Richards met with Jahi Simbai and processed data from past surveys of students that did not accept the Mines offer and put together (with Kay Schneider) surveys for current students as well as those in departments dealing with graduate student admissions. It should be noted here that there was also a plan to run panels with each of the groups to further prioritize areas of improvement; these panels are anticipated to be coordinated with the interim Dean of Graduate Studies (Tina Voelker). From the data that we were able to process, the most important factors for recruiting are web presence, fellowship/assistantship, quality/ranking of program, stipend amount, and interaction with faculty. A number of these ideas were discussed with the Mines Foundation and it was indicated that there could be some appetite amongst the donor community for supporting graduate students; a prioritized list should be compiled for the administration to consider and potentially develop concepts for marketing to donors.

In summary, the Research Task Force recommends:

Organizational/System Issues:

1. Assess graduate program ranking systems and how to maximize Mines standing.
2. Formalize, highlight, and advertise the Mines/NREL collaboration.
3. Assess the current housing situation with Mines Park (or other on campus housing) and consider prioritizing first year graduate students and visiting scholars or reserving space for their presence.
4. Assess if graduate studies are being funded at a level proportional to their numbers on campus (i.e., are we putting enough resources into graduate students; and have graduate student numbers grown as undergraduate student numbers have grown).
5. Coordinate recruiting open-house visits. A pilot program for some departments is in place by the Grad School for Fall 2016 admissions.

Resource Issues (will cost money):

1. Increase funding for on-campus visits.
2. Offer prestigious fellowships/more competitive stipends.
3. Increase recruiting efforts.
4. Develop jointly funded graduate opportunities with NREL.
5. Work to improve campus life for graduate students.

## b. Work Load

In order to grow our research enterprise, the TF felt it was important to understand our current “human capital”, from both a workload perspective and a research impact perspective. The Research Task Force understands that Mines spends ~\$7.5 million/year on research through 40% faculty release time from teaching associated with our 40/40/20 research/teaching/service model. In addition, Mines spends a significant amount on adjuncts (~\$1 million) and TAs (~\$2.4 million) each year in order to assist with the teaching enterprise. These funds represent a substantial investment by the university. Is Mines being strategic with these expenditures?

To help answer this question, the Research Task Force gathered data on:

- Research “load” (assessed by research expenditures),
- Research “impact” (assessed by citations/h-index), and
- Teaching “load” (assessed by student credit hours).

The Research Task Force understands that these metrics do not precisely assess faculty load/impact, but they do provide some insights.

Each faculty member was given an ID based on research expenditures from the 2014-15 AY, sorted from most expenditures to least expenditures. Appendix A1 shows these expenditures for each faculty rank at Mines. For Full Professors and Associate Professors, we also provide the average research expenditures for the faculty in the top 50% of research expenditures and the average research expenditures for the faculty in the bottom 50% of research expenditures. For Assistant Professors we only provide the average research expenditures for all Assistant Professors, which we note is almost 5x higher than the bottom half of the Associate Professors and 3x higher than the bottom half of the Full Professors.

As shown, our campus is quite diverse in terms of how much research funding is spent each year. We also note that not all disciplines at Mines are the same, e.g., some disciplines have expensive equipment that needs to be purchased for research tasks while other disciplines have very few funding sources. However, from a workload standpoint, one could argue that those faculty members with higher expenditures have a higher load than those faculty members with lower expenditures (due to proposal writing, tracking finances, etc.).

Of course, faculty with low research expenditures can have significant research impact. We, therefore, collected data on citations/h-index from three sources, Google Scholar, Research Gate, and Web of Science. These data are plotted in Appendix A2-A4 by faculty research ID<sup>1</sup>. The data in the figures make one point quite clear. For both Full Professors and Associate Professors, faculty members with higher average research ex-

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<sup>1</sup> Faculty IDs with a negative citation/h-index indicate that we were unable to locate data for that faculty member, e.g., faculty member does not have a Google Scholar profile.



penditures consistently have higher average citation rates and higher average h-index values (true for all data sources). We also note that sometimes the difference in these averages is quite significant. In short, using our definition for load and impact, the Research Task Force concludes that faculty with higher research expenditures (on average), have higher workload and higher research impact (on average) than faculty with lower research expenditures.

From a fairness point of view, one might then expect that those faculty members with lower research expenditures and lower research impact carry more of the teaching load on campus. Appendix A5 illustrate this is not the case for Full and Associate Professors (teaching load data gathered from the 2014-15 AY). Furthermore, Appendix A5 illustrates that Assistant Professors have (on average) the same teaching load as Associate Professors with lower research expenditures and a larger teaching load than Full Professors with lower research expenditures.

Unfair workload hurts faculty morale on campus and needs to be addressed. The Mines current faculty handbook only provides guidance for T/TT faculty workload as 40/40/20 for research/teaching/service percentages. The data provided shows that Mines faculty are not the same; thus, we believe our current 40/40/20 workload guideline should be improved.

In summary, the Research Task Force recommends:

1. Mines administration develop a new faculty workload model for Mines T/TT faculty. Included for consideration is an example model from ASU (A6) provided by the President.
2. Mines adopt a culture where teaching is valued. For example, Mines currently has a way for faculty to “buy out of teaching” (via research funds); we recommend that Mines provide a way for faculty to “buy out of research” (via increased teaching load).
3. All Mines T/TT faculty members be required to create a Google Scholar profile to track Mines impact in research. We recommend Google Scholar because this site is the easiest to maintain (i.e., the site updates automatically once the profile is created). In addition, all Mines research active faculty should have their own websites to further outreach the broader community and be a portal for recruiting graduate students.

### c. Faculty Mentoring

Mines faculty understand the importance of faculty mentoring. As mentioned earlier in this report, the Research Task Force asked Mines faculty “what do you need to grow your research enterprise (where you can define growth however you want)?” Many responses from this question fell into the “need research mentoring” category.

Research has shown that quality mentoring is key for faculty success. Therefore, Mines has provided new faculty mentoring for years and, more recently, hosted a few group mentoring events where all faculty were invited. One example of a group event in Fall

2015 was a session on “Getting Funded”. This session began with a presentation on “How to Write Compelling Proposals” and ended with several round tables led by faculty who are experts/well-funded from NSF, NIH, DoD, DoE, and Industry. Approximately 40 Mines faculty attended this event, and ratings from the post-event survey were quite high. The Research Task Force recommends that Mines host at least two events such as this one each semester.

Individual mentoring is also key for faculty success. To understand the landscape of formal mentoring programs at Mines, the Research Task Force asked a tenured faculty member (mainly a Full Professor) in each department to describe the mentoring program that exists in the department. We then classified each mentoring program into one of three categories:

1. Good Program: the department has a formal mentoring program that appears to be working well.
2. OK Program: the department has a formal mentoring program that appears to be working well, but the program could be improved (e.g., the department has a formal program for the Assistant Professors, but nothing for the Associate Professors).
3. No Program: the department has no formal mentoring program (e.g., “junior faculty can talk to any of the senior faculty for advice”).

The results from this analysis follow:

1. Good Program: 2 departments at Mines.
2. OK Program: 6 departments at Mines.
3. No Program: 6 departments at Mines (where 2 departments are in the process of creating a formal program).

In our discussions with faculty, many faculty stated that the value/success of mentoring within the department depends on the current department head. That is, if the department head thinks mentoring is valuable, then there is a focus on mentoring within the department. This fact indicates a need for a university-wide program that is not dependent on the current department head’s view on the subject of mentoring.

In summary, the Research Task Force recommends that

1. Mines continues (and perhaps expands) the new faculty mentoring that occurs in August each year, such that research mentoring is a key aspect of this event.
2. Mines hosts at least two mentoring events each semester where all faculty are invited to attend.
3. Mines adopt university-wide guidelines that help specify what departments should be doing for individual faculty mentoring.

#### d. Reduction of Administrative Burden on the Faculty

In general, research active academic faculty feel very busy due to the constant demands related to teaching, scholarship, and service; this perspective was embedded in the previous comments related to workload. As the Research Task Force engaged faculty across

campus, a number of topics were identified by faculty as meaningful issues for multiple faculty. While the following paragraphs provide commentary on several subjects, we note that the two issues of greatest concern were industry contract negotiations and simplified (“checkbook” accounting) for research projects.

#### Pre-Award

Campus dialogue related to “decentralization” of some functions of the Office of Research Administration (ORA), e.g., pre-award issues related to proposal development and budgeting, were not a critical concern of the faculty. This seems to be an indication of improvements in some of ORA’s processes as such concerns were substantial a few years ago. The institution may benefit from improved processes related to development of large proposals (for example, utilization of proposal writers), but this topic was not thoroughly discussed by the Research Task Force.

#### Post-Award

Issues related to industry contract negotiations were discussed, as the Research Task Force is aware of substantial concerns in this area, including first-hand experiences of Task Force members. In essence, negotiations with companies can become bogged down for lengthy periods of time after the decision is made by these companies to sponsor research at Mines. Research funding has been lost over the inability to negotiate acceptable terms, leading to considerable frustration on the part of sponsors and researchers. Responses by Mines administration have sometimes been untimely during the negotiations, straining the sponsor/Mines relationship, and PIs have sometimes requested special assistance from senior administration to help “save” their negotiations. The Task Force’s perspective is that timely responses should be a minimum expectation, and some procedures to better deal with common challenges (intellectual property, state regulations) may be helpful. These topics were discussed with representatives from ORA, Finance and Administration, and Technology Transfer. Damage to sponsor relationships may be unavoidable in some instances due to intractable differences between the parties, but hopefully we can avoid situations where contracts are lost due to lack of a timely response in contract negotiation. During the Task Force’s study period, a new hire was made in ORA to help address these issues and reduce the backlog of negotiations. Because this change is recent, it is difficult to propose additional action pending further experience. However, some clear commitments related to maximum turnaround time between communications and management oversight/communication related to the backlog would be appreciated by faculty to track performance in this area. There may be some broader opportunities to streamline negotiations by offering, for example, an option for industrial sponsors to purchase IP rights at a standard rate, but the Task Force did not discuss such opportunities in depth.

The issue of “checkbook” accounting relates to the use of the Banner system for detailed tracking of budgets and expenditures for individual research project accounts, Foundation accounts, and professional and research development accounts. The faculty perception is that this system is more suited to operation by accounting professionals, whereas occasional use by faculty is challenged by non-intuitive characteristics of Banner operation, difficulties in drilling down to investigate transaction details, and a general lack of

understanding for how many funds are actually available to spend in a given account at a given time. This concern has been in place for many years, and Guggenheim staff members are typically helpful in assisting faculty and support staff in their accounting efforts. Nonetheless, faculty are comfortable managing their personal finances with available systems that present fewer challenges, and intuitive systems for project accounting would be greatly appreciated if available. This discussion also touched on the number of various software products in use on campus. These products have improved and automated administrative processes, but are sometimes perceived as transferring new responsibilities to faculty. A faculty member may be called upon to work with a half dozen different software programs and/or websites to carry out various administrative tasks, which adds confusion. Thus, adoption of software systems that involve faculty users should be tailored for simplicity of occasional users, in addition to the functions needed by expert users who use the systems more frequently.

#### Other Issues

The Task Force discussed the innumerable compliance requirements related to federal and state government rules that impact many aspects of research and student interactions, as well as industrial sponsor requirements and Mines policies and regulations. These requirements are perceived as an additional “burden” on faculty, although the Task Force did not identify “low hanging fruit” that could be harvested through simple changes. The President’s commitment to work with faculty to try to identify and modify “silly rules” is appreciated by faculty.

The discussion of faculty workload presented earlier in this report addresses the balance of teaching and research. Service represents the “third leg” of the workload triangle, which must be recognized in some way when analyzing workloads. Research active faculty (and others) are often engaged in external professional service in addition to institutional and departmental committees, and quantification of such effort is difficult. However, the Research Task Force did not explore this issue extensively or identify specific recommendations.

#### e. Interdisciplinary Research

One of the most important attributes of a vibrant and ambitious research and education program is the ability to cross formal boundaries between disciplines and to form interdisciplinary teams addressing major societal challenges. Based on feedback from the faculty, as well as on our own careful analysis, the Research Task Force found that we can take significant steps in the direction of increasing cross-campus collaboration, with emphasis on interdisciplinary research and education. Some of those steps concern the campus culture, while others refer to short-term and medium-term administrative actions. Some of the proposed changes are low-cost, while others require significant and sustained investment over the medium and long term. While many possible strategies could be employed to address this problem, we focus on three that have the potential for the highest return and biggest impact.

### Campus-wide research communication

One of the most significant impediments to the development of a dynamic interdisciplinary culture at Mines is the fact that most faculty are simply unaware of the research conducted by fellow faculty/researchers outside their home units. This is certainly true within colleges, but it is even more true among colleges. It is difficult for anyone to identify and/or engage in collaborative research without at least knowing what others are doing elsewhere within our own home institution. This situation is not by design, but simply an unfortunate byproduct of our own time shortage resulting from existing time commitments.

Our recommendation is to begin to address this problem by creating systematic opportunities for crosstalk between faculty/researchers/students of all units on campus. Specifically, we propose to institute research communication days (RDs) with presentations of existing and/or new research from different units to the entire campus. We can structure these Research Talks on the model of TED<sup>2</sup> talks (e.g., 20 min long presentations on different subjects extracted from our existing scientific portfolio). We could perhaps organize such Research Talks every 3 months, to allow for a regular and broad survey of our existing research portfolio. Some of these events could focus on a specific College, while others could mix speakers from all colleges.

Such activities are likely to succeed if:

- we keep them short (one half day with a limited number of technical talks),
- we do not overlap them with any other seminar or workshop on campus,
- we do not schedule any classes during this time to allow full participation,
- we give high profile to such events (e.g., use the label President's Talks),
- we record the presentations for later web distribution, and
- we follow the event with a short reception for further interaction.

We hope that these activities will increase our mutual understanding of the current campus research, and will also help identify opportunities for collaboration on existing and/or new projects. This recommendation is primarily focused on a cultural change and will take time to bear fruit, but increased transparency can only benefit our campus as a whole.

**Implementation:** campus research days in the administration of the VPR office; college research days in the administration of the Deans offices.

### Interdisciplinary research seed funding

More systematic technical communication can increase awareness and stimulate various researchers to work together. However, many ideas are unlikely to take off simply due to the unavailability of time and, perhaps, necessary seed funding. Most new and risky ide-

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<sup>2</sup> TED stands for Technology Entertainment Design, [www.ted.com](http://www.ted.com).

as benefit from immediate seed funding to explore them in greater depth, or to acquire basic equipment, before any formal proposal is formulated, filed, or approved many months later. A small and well-timed push can stimulate an unlikely project and make the difference between an actionable or an abandoned idea.

It is highly unlikely that any one person knows precisely where such seed funding ought to be directed. It is far more likely that this becomes a successful effort if we decentralize the decision to different levels of the administration. Department Heads/Division Directors, Deans, and the VPR are likely to have different perspectives of the campus and to identify interdisciplinary activities at different scales. For example, the DHDDs could focus on interdisciplinary research within their units, Deans could seek interdisciplinary opportunities among the departments in their portfolio, and the VPR could stimulate such opportunities among colleges at the scale of the entire campus. This decentralized multi-scale approach is likely to cover the widest spectrum of opportunities; furthermore, some activities could be supported at multiple administrative levels.

This program is likely to succeed if:

- significant research funding is available at all levels of responsibility,
- funds are directed specifically for interdisciplinary activities, and
- seed funding availability is transparent and administered openly.

The net result is that DHDDs, Deans, and VPR function like Venture Capitalists, who have both the means and the responsibility to turn relatively modest funding into engines for research growth.

We propose to support this program with funds obtained in equal measure from research grants (e.g., IDC return), and from other institutional funds that currently get distributed indiscriminately among all campus researchers, regardless of their research effectiveness. We are perfectly aware that IDC return is a touchy subject and might raise concern among the faculty. However, we think that this proposed program could be embraced broadly by the campus researchers:

- if this program is transparently administered and all funds are directed strictly toward publicly announced interdisciplinary research,
- if funding is available to all campus researchers in all units, and
- if the available funding comes with a 1-to-1 match between institutional sources and IDC return.

Using these mechanisms, all research-active faculty would recognize that they could get access to a larger funding pool than would otherwise be returned to them from the IDC.

**Implementation:** funds budgeted annually using a fair and transparent system; execution responsibilities rest at the department's level with accountability along the usual reporting lines.

### Standalone interdisciplinary units

Research awareness through open Research Days and research acceleration/initiation through discretionary seed funding can make a big impact in the development of an interdisciplinary research culture on campus. However, these mechanisms are limited in scope, in that they concern research ideas that already exist and have a champion among the faculty. These actions are not transformative in nature, but rather focus on higher efficiency of launching one-off interdisciplinary research efforts.

We propose to pursue the next step by developing a small number of interdisciplinary research and education units, designed on the model of the MediaLab at MIT and other such units at different notable schools. Such research/educational units have demonstrated to be highly effective at stimulating interdisciplinary research and can serve as transformative catalysts both within their home institution and for the society at large.

Without being exhaustive, here are some of the key attributes of the proposed interdisciplinary units:

1. One core attribute of such research/educational entities is that they are **interdisciplinary by design**, i.e., group together scientists with completely different backgrounds who are simply motivated by the pursuit of problems with huge societal impact (e.g., the state of the Earth from the perspective of climate change, energy use/production, sustainable food production, access to clean water) Such problems fit the core of the research and educational portfolio at Mines, but can be addressed in novel and creative ways only through efforts of unlikely combinations of scientists with different backgrounds.
2. A second core attribute of such units is that they function **outside the college/department structure**, since they are not meant to replace any of the existing research. Instead, their goal is to stimulate the emergence of new research at the intersection of multiple scientific fields, in a space that lacks any kind of disciplinary walls, either among the faculty or the students. Because of this, such units function best both as research programs, but more importantly as academic programs focused on educating the next generation of scientists who are open-minded and ready to address big societal problems.
3. A third core attribute is that such interdisciplinary research units often **function in connection with business incubators** or research parks. This association has multiple mutual benefits, by quickly taking research ideas to the marketplace, by supporting a large group of scientists who can function as Research Faculty in the School, by providing hands-on experience and internships to students, by generating research funding, and by developing a strong intellectual property portfolio.

We see many other benefits to this interdisciplinary research structure and we propose that this model be further investigated and refined in the near future for implementation in the medium term. Aside from great science supported by existing and new Mines faculty, such entities need good infrastructure and facilities designed specifically to stimu-

late interaction, collaboration, and serendipity. We recognize that this initiative requires significant investment from the school; however, we also recognize that this initiative can raise the profile of Mines to a new level and be transformative of our research and educational portfolio in the long term.

We emphasize that the proposed interdisciplinary research unit is not equivalent to a Center, even a large one. Centers usually bring together people of similar specialty, perhaps even from the same discipline. Just because many researchers with similar backgrounds are grouped administratively together does not mean that they address the same problem from multiple perspectives, and even less that they engage in novel interdisciplinary research. What we propose involves much deeper integration outside the conventional disciplinary organizational charts. Moreover, in contrast with the setup common for a conventional Center, student members of an independent interdisciplinary unit develop in an educational environment that exposes them to different viewpoints of a given problem and encourages them to explore novel approaches outside their core expertise. This arrangement seeks to integrate diverse disciplines and skills, thus leading to non-conventional solutions to complex problems.

An indirect benefit of the proposed interdisciplinary units is that they can function as focal points for energetic fundraising through the Mines Foundation. Such high-profile interdisciplinary units can stimulate the energy of unlikely donors who would want to associate themselves with an ambitious and far-reaching initiative addressing major societal challenges. We envision that this could lead to a virtuous circle where fundraising for distinguished faculty chairs, talented graduate students, and high-profile visitors from the industry/government/academia leads to consequential research, which in turn raises the profile of the institution, thus stimulating additional and increased fundraising.

**Implementation:** VPR forms a study group to generate within 3-6 months a full proposal for consideration by the Mines faculty and administration.

In summary, the Research Task Force recommends that:

1. Mines proceeds with annual or bi-annual faculty conferences dedicated exclusively to research communication, with particular focus on interdisciplinary science.
2. Mines significantly expands discretionary funding available to the VPRTT, Deans, and possibly DHDDs to stimulate interdisciplinary research across departments under their supervision.
3. Mines proceeds with a detailed study of the mechanisms needed to set-up interdisciplinary research units on the model of the MIT MediaLab, but with focus on specific CSM strengths.

#### f. Grand Challenge Research Institutes

Despite significant growth of our research enterprise over the past decade, a review conducted by the Research Task Force leads to the conclusion that we have room to grow further in terms of quality, quantity, and especially the impact of our research. Many steps can be taken toward these goals, some of which can bear fruit in the near term



without big changes to the existing institutional structure, while others require a longer-term view and substantial commitment from our institution. In this section we refer primarily to steps in the latter category, which in our opinion can put us on a significant growth trajectory and can also change some of the makeup of the faculty and student body. Our primary focus is on the interdisciplinary character of our research and on the efficient use of our research infrastructure.

The Task Force, with support from Mines faculty, believes that research at Mines can be enhanced through restructuring of research centers on campus and through establishment of research institutes that are intrinsically interdisciplinary and mission-oriented. We envision such organizations as complementary to the existing research infrastructure and primarily based on the scientific expertise currently available on campus. The main goal of reorganizing research centers on campus is to establish new research bodies that are more efficient in space and allocation and utilization of resources, and ambitious in pursuing solutions to major research challenges. An institute, or large center, will overcome the institutional barriers that hamper or discourage a higher-level cooperation on strategic research.

The main driver for this initiative is the realization that many of the significant problems facing society in the near and longer terms can only be addressed by integrated teams consisting of experts in different fields, rather than by isolated disciplinary teams. Our current research structure appears to encourage disciplinary research through our separation into many concentric organizational circles that distance researchers from one another. This is certainly effective in many instances, as evidenced by our research growth in many fields, but it is not the ideal structure for integrated research aimed at addressing major challenges that societies are facing today (e.g., climate change, renewable energy, food production, access to safe water, aging infrastructure and national security). Such challenges require that we rethink how we structure our activities and how we better exploit the scientific and engineering talent available at Mines.

This kind of transformation/transition is not new and not specific to Mines. Other large and successful academic institutions came to the same conclusion over time and proceeded to form new, transformational, and translational research structures that begins with a 'blank sheet' and are not hampered by historic institutional mechanisms. In all cases, the goal is to bring people together and share resources more efficiently, but most importantly to facilitate interdisciplinary science and education. Examples of institutes that went through these changes include:

- the MediaLab at MIT ([www.media.mit.edu](http://www.media.mit.edu))
- the d.school at Stanford ([dschool.stanford.edu](http://dschool.stanford.edu))
- the iLab at Harvard ([i-lab.harvard.edu](http://i-lab.harvard.edu))
- the Energy Institute at CSU ([www.energy.colostate.edu](http://www.energy.colostate.edu))

These organizations, and others like them, are very well regarded in the scientific community due to the caliber of their research, the quality of their faculty and students, and the volume and impact of their research. A great example of a purposefully designed in-

terdisciplinary organization is the MIT MediaLab<sup>3</sup>, whose main characteristics can function as a model for a similar type facility at Mines:

1. The MediaLab was designed several decades ago **to address a major challenge** posed by the development of computer infrastructure and new ways of human/technology interaction. Many of the techniques developed at the MediaLab are in common use today and have removed seemingly unmovable barriers.
2. The MediaLab **focuses on** applications of technology to **problems with a significant social component**. This is essential in order to gain public recognition and support from the community at large, as well as from local and university administration.
3. The MediaLab effectively **functions outside the departmental structure** of its home institution. Although the Lab is formally part of an existing MIT college, it has its own nimble administration designed to support high-risk research activities and to minimize bureaucratic burden. The MediaLab even has its own admissions policies focused on recruiting the most talented graduate students who can straddle disciplines and pursue interdisciplinary goals. The Energy Institute at CSU (PowerHouse) has a similar structure.
4. The MediaLab is not only a research organization, but also functions as **a distinct degree-granting academic program**. This is essential in channeling the attention and energy of the participants in the program, both faculty and students, to the core challenges addressed by the Lab. Moreover, this system **facilitates education innovation** through creative blending of teaching and research activities using modern hands-on tools.
5. The MediaLab **builds upon the scientific strengths of its home institutions**, by taking full advantage of the MIT knowledge base in Computer Science, Robotics, and Engineering. However, the faculty of the MediaLab come from different disciplines (computer science, engineering, biology, physics, neuroscience) to facilitate research that is not discipline-specific, but mission oriented toward high-impact societal challenges.
6. The MediaLab **brings together its entire associated faculty in a single research facility**, which is designed to encourage spontaneous collaboration through shared lab spaces and support, serendipity through open research space, and transparent cross-pollination through lab-wide workshops, courses, and seminars. The critical mass obtained by concentrating large numbers of faculty and students from diverse disciplines encourages research at a scale that cannot be attained by any individual research group.

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<sup>3</sup> *Actively promoting a unique, anti-disciplinary culture, the MIT Media Lab goes beyond known boundaries and disciplines, encouraging the most unconventional mixing and matching of seemingly disparate research areas. It creates disruptive technologies that happen at the edges, pioneering such areas as wearable computing, tangible interfaces, and affective computing. Today, faculty members, research staff, and students at the Lab work in 24 research groups on more than 350 projects that range from digital approaches for treating neurological disorders, to a stackable, electric car for sustainable cities, to advanced imaging technologies that can “see around a corner.” The Lab is committed to looking beyond the obvious to ask the questions not yet asked—questions whose answers could radically improve the way people live, learn, express themselves, work, and play. (www.media.mit.edu/about)*

7. The MediaLab **is supported** to a large degree **by institutional grants**, rather than grants for a specific researcher. This naturally encourages integrated research, but also facilitates partnerships with major industrial sponsors who seek bold scientific breakthroughs, rather than timid incremental improvements of existing technology.
8. The MediaLab **strongly encourages entrepreneurship** and functions as an incubator for startup companies. This benefits the lab by complementing its faculty with talented research faculty involved in the associated startups, by expanding the funding base for the lab, and by involving students during their studies in real-world applications of their academic research. The MediaLab is also aggressive in acquiring and defending IP rights and in supporting startup activities.
9. Based on its existing and developing reputation, the MediaLab **attracts ambitious and creative faculty and students**, thus creating a virtuous cycle linking high-caliber research with massive financial support with best human talent available.
10. The MediaLab structure **recognizes that scientific and engineering advances go hand-in-hand**, and thus its researchers pay equal attention to both fundamental research, and practical applications.

We recommend that Mines embrace a similar model adapted for our strengths and targeted toward accomplishing the main objectives stated in our strategic plan. We could form one or more research organizations (a.k.a., institute, or lab, or observatory):

- Focused on the study of the **Earth system** (e.g., water, climate, energy, food)
- Building upon our **institutional strengths** (e.g., earth sciences, engineering)
- Using **interdisciplinary** teams (e.g., geoscience + space + robotics + computing)
- Located in a **high-profile/central campus facility**
- With a **flat administrative structure**, outside the colleges, and reporting to the VP level
- With graduate/undergraduate **degrees without specific disciplinary labeling**
- Connected with a **research incubator** located on or close to the campus.

A Mines structure of this kind could in time become a top-tier research organization that would elevate the overall Mines research profile, attract talented faculty and students, increase the available research funding, and most importantly raise the impact of our research to a new level. Such an organization could also serve as a model for new mechanisms for research administration that over time would permeate the entire organization and lead to a more nimble and decentralized organization overall.

Such an organization would not only have strategic importance for our institution by attracting research funding and channeling efforts toward grand challenges, but would also function as a focal point for vigorous fundraising by the Mines Foundation to increase support for:

- High-profile **endowed chairs** in strategic disciplines
- Competitive graduate and undergraduate **research fellowships**
- New and modern **research facilities**
- Highly skilled **research and lab staff**
- **Teaching innovation** and professional development

- High-impact, short-term **visitors from the industry and academia**, and
- **Public communication** of science and community outreach.

This new type of research organization will require steady and long-term commitment from our institution, and also investment of financial and human capital; but the payoff can be significant. For example, the research budget of the MIT MediaLab with about 30 faculty and 250 graduate students, and 80+ members was about \$50M in 2014-2015, which is comparable with the overall research budget of a much larger organization like Mines.

*An example: A Mines Water-Energy Institute*

While plans to establish new materials/energy institutes on campus are underway (A7), Mines has a special strength in water and energy (and their synergy) research. Research conducted on campus in these areas is performed through the following research centers:

- Center for Experimental Study of Subsurface Environmental Processes (**CESEP**),
- Advanced Water Technology Center (**AQWATEC**),
- Center for Environmental Risk Assessment (**CERA**),
- Integrated GroundWater Modeling Center (**IGWMC**),
- NSF Engineering Research Center for Reinventing the Nation's Urban Water Infrastructure (**ReNUWIt**), and
- ConocoPhillips Center for a Sustainable Water-Energy Education, Science, and Technology (**WE<sup>2</sup>ST**).

Almost all of these centers are unique in their infrastructure and the research conducted, and most of them are already nationally and internationally recognized. However, minimal collaboration exists between these centers and the synergy and opportunities that can be achieved from their cooperative operation are lost. Furthermore, the Humanitarian Engineering Program at Mines, which is a very unique program nationwide, is not integrated into the general water research on campus, and neither are others on campus that do research on the political, social, and scientific aspects of water, energy, food, and air.

Therefore, it appears that Mines has already achieved the critical mass of research, facilities, talent, and resources for establishing a water institute (or water-energy institute), which will facilitate acceleration of research in very unique and important fields with significant impacts on society. A new water-energy institute will also benefit from local and established collaborations with federal agencies such as NREL, USGS, Bureau of Reclamation, NIST, and NCAR, and with many high-tech industries in the Denver metro area.

There are, however, other water institutes across the country and we should understand what could make a Mines water institute unique. A few examples of other water institutes across the country include:

- [The Water Institute at UNC: Water Institute,](#)
- [University of Florida Water Institute](#)
- [CSU Water Institute](#)
- [Johns Hopkins Water Institute](#)
- [Purdue University Calumet Water Institute \(PWI\)](#)
- [University of Illinois Safe Global Water Institute](#)
- [California Institute for Water Resources](#)

The directors of the water-related centers at Mines have started the discussion and are planning to introduce a proposed program for transforming into a water or water-energy institute at the beginning of 2016. As we move forward, special attention must be paid to the investments needed for it to succeed. These investments in infrastructure and reorganizations should be thoroughly explored and discussed among researchers, department heads/division directors, deans of colleges, and campus administrators to ensure best outcomes. This can be done through establishment of a special task force in charge of establishing each institute.

Some of the topics that require specific attention include:

- Requirement for a centralized **physical infrastructure** for an institute:
  - Labs and offices (faculty, staff, postdocs, students);
  - Both science, engineering, and policy components of research.
- **Incubators** as part of the infrastructure (startup companies):
  - Self-supported enterprise (other institutes are able to cover both operating and capital expenditure through renting out space to startup companies).
  - Potential for UG and graduate experience as interns with the startup companies occupying the incubator space.
  - Institutional barriers must be overcome to allow faculty, staff, and students to be an integrated part of the incubator enterprise.
- Legal barriers to SBIRs and startups on campus?
- While combining existing research centers into an institute, it is important to maintain the **legacy** of existing entities/centers. Furthermore, special centers such as ERCs (ReNUWIT) and donated centers (WE<sup>2</sup>ST) are unique entities and their integration into an institute is not obvious or simple.
- **Institutional support** is needed, at least in the short term, in order to facilitate successful startup of an institute. These include attractive IDC return, technical staff support (technicians, lab managers), and administrative support to assist with finance, research management, proposals, and contracts.

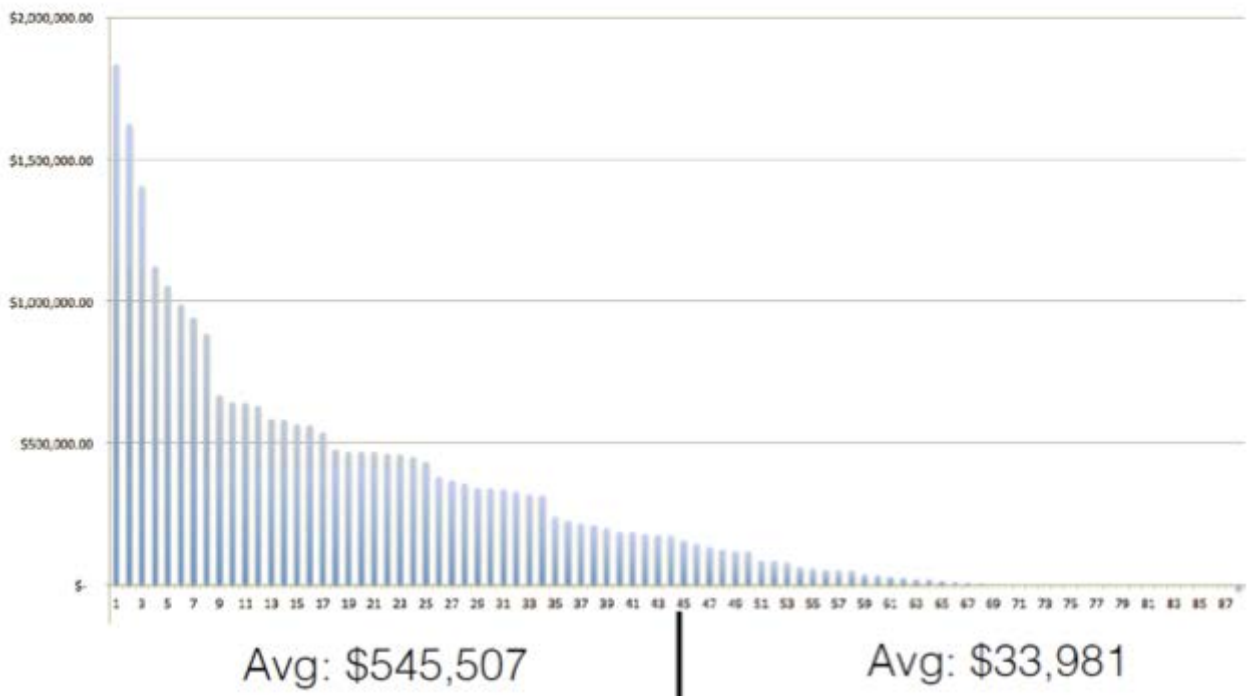
Other issues to consider while planning the transition into an institute-derived research include:

- Who will oversee the operation of the institute(s)? VPRTT? Deans?
- What will be the relationships with colleges and departments?
- What management structures worked best for other institutes?
- What will be the funding mechanisms for an institute?
- How infrastructure will be managed, maintained, allocated, and efficiently utilized?

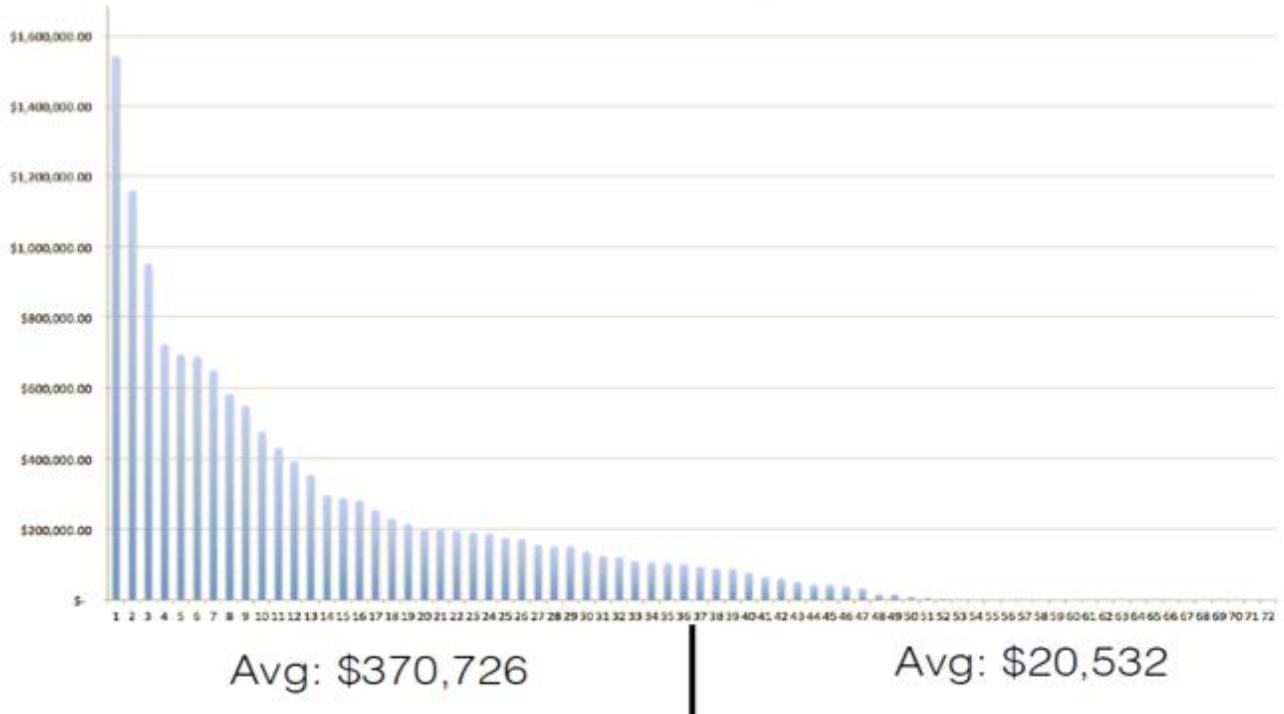
V. Appendix

# A1: Research Expenditures

## Full - Expenditures



# Associate - Expenditures

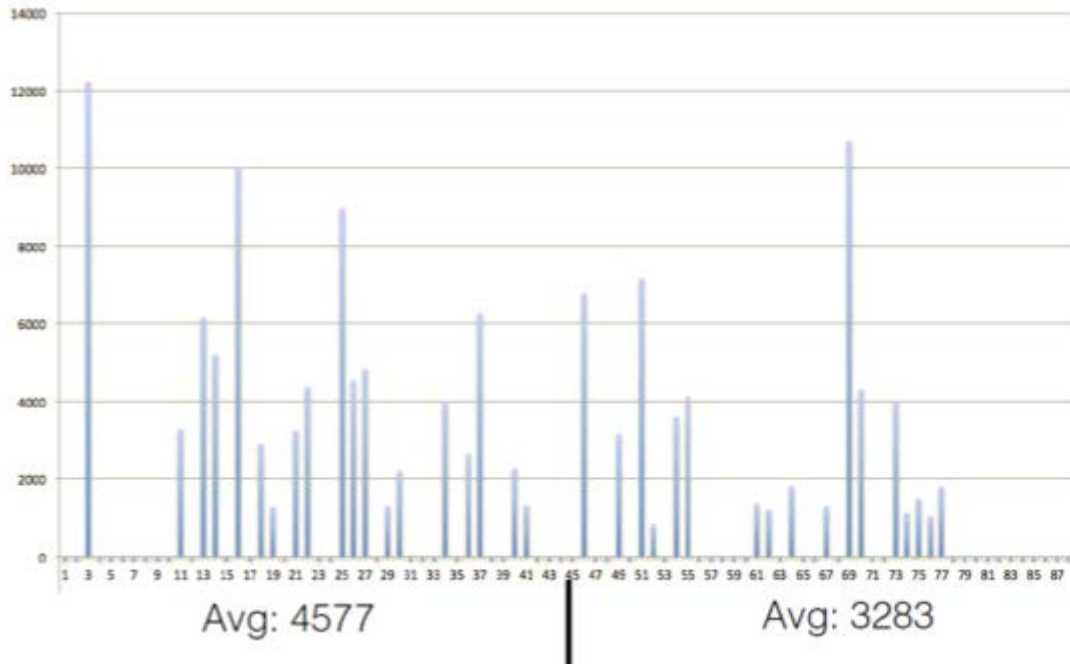


# Assistant - Expenditures

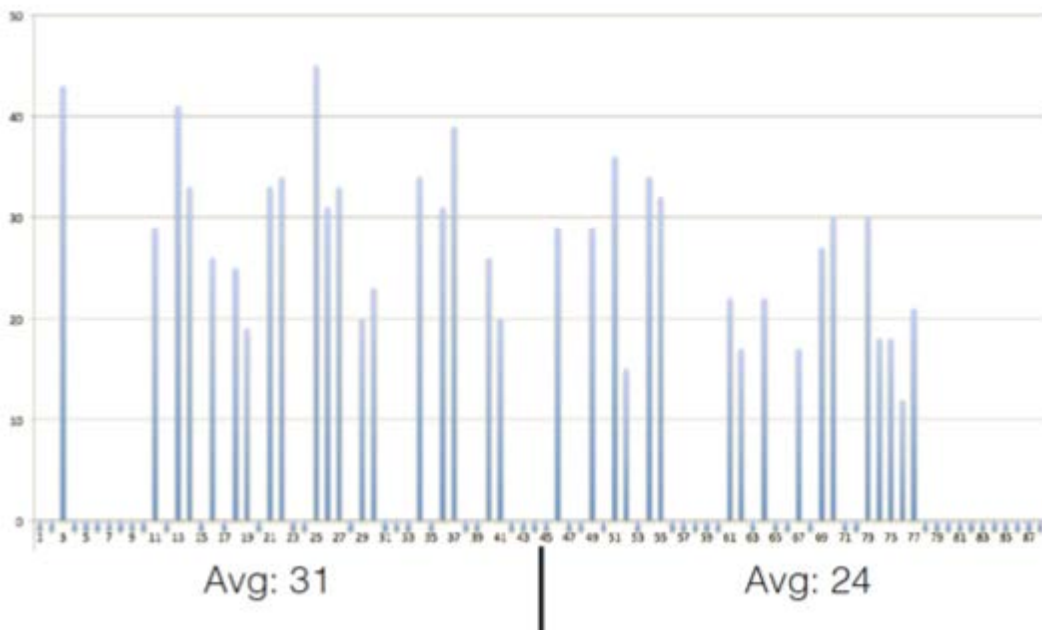


## A2: Full Research Impact

### Full - Google Scholar Cites

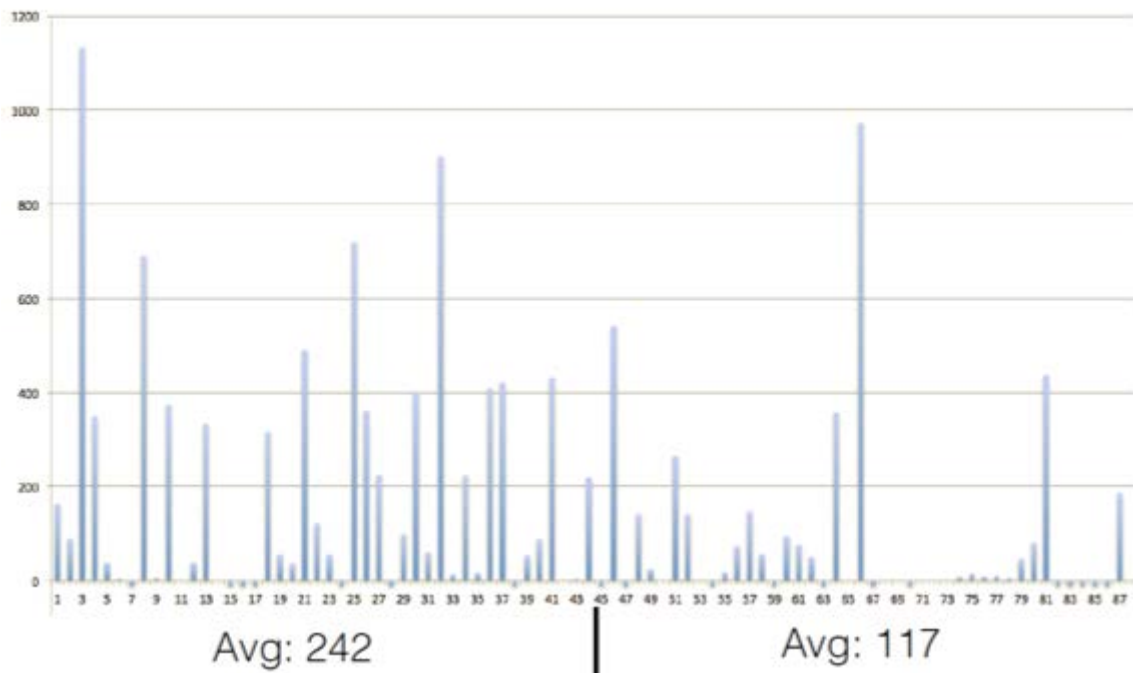


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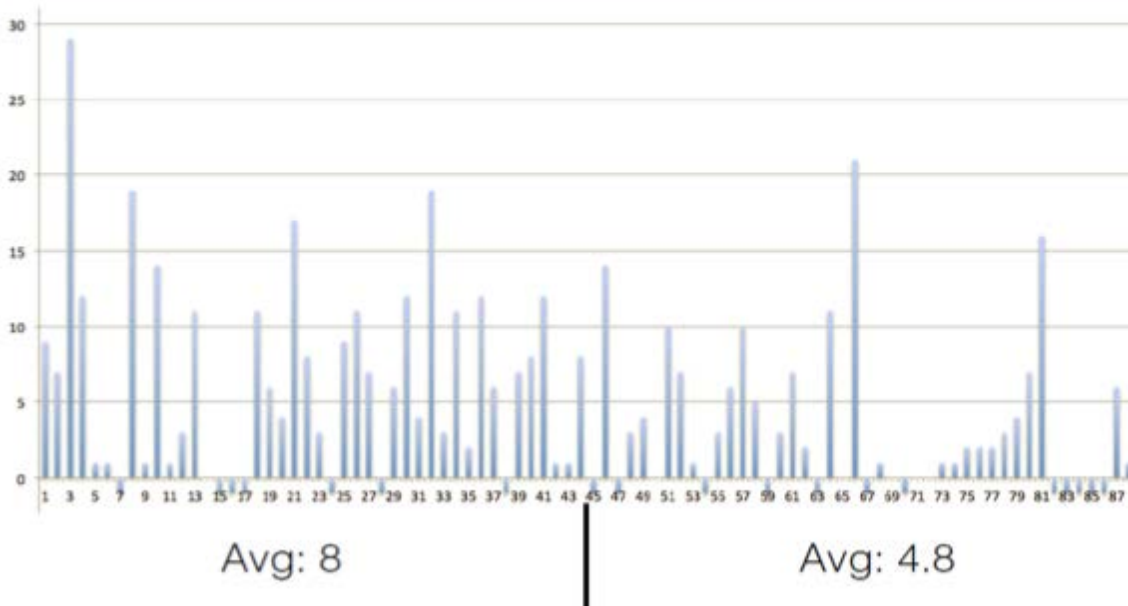




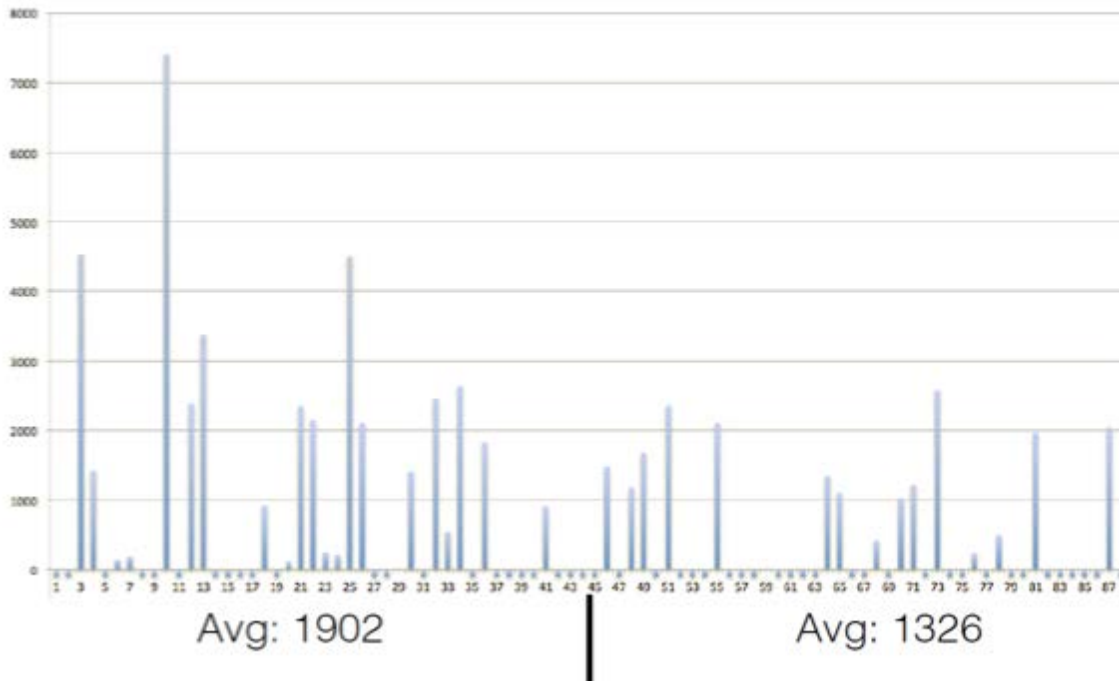
# Full - Web of Science Citations



# Full - Web of Science h-index

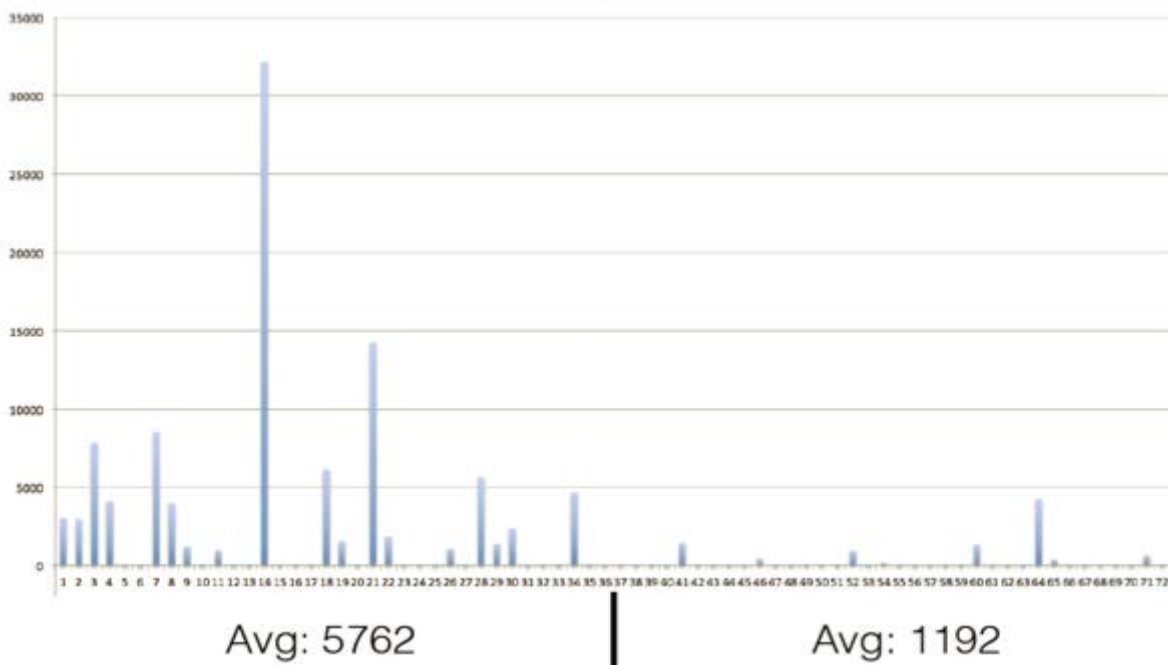


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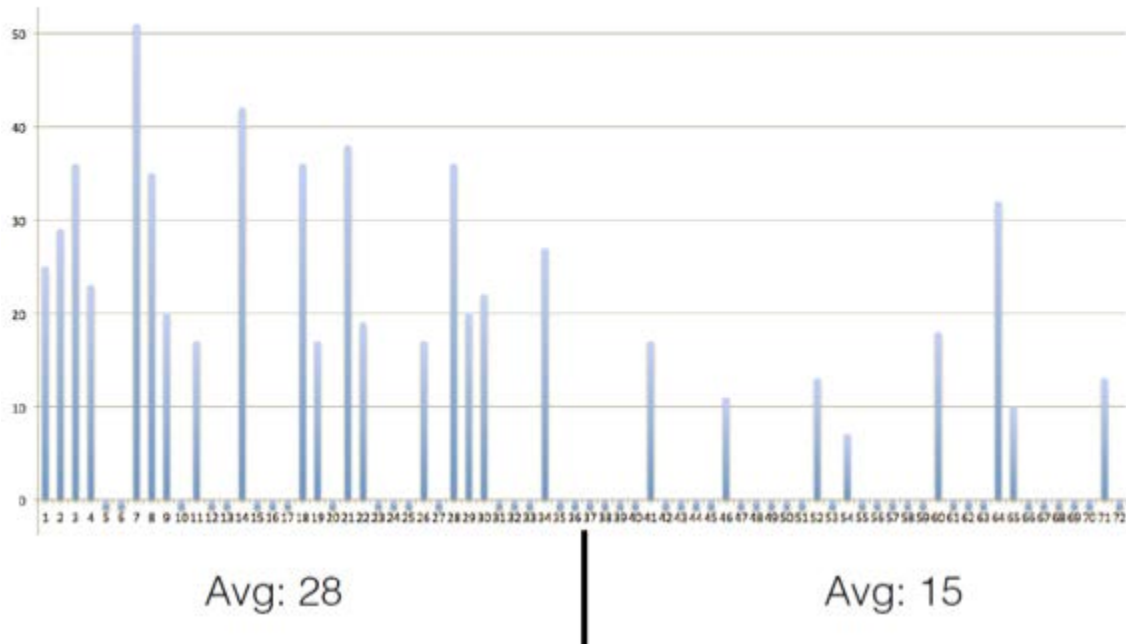


## A3: Associate Research Impact

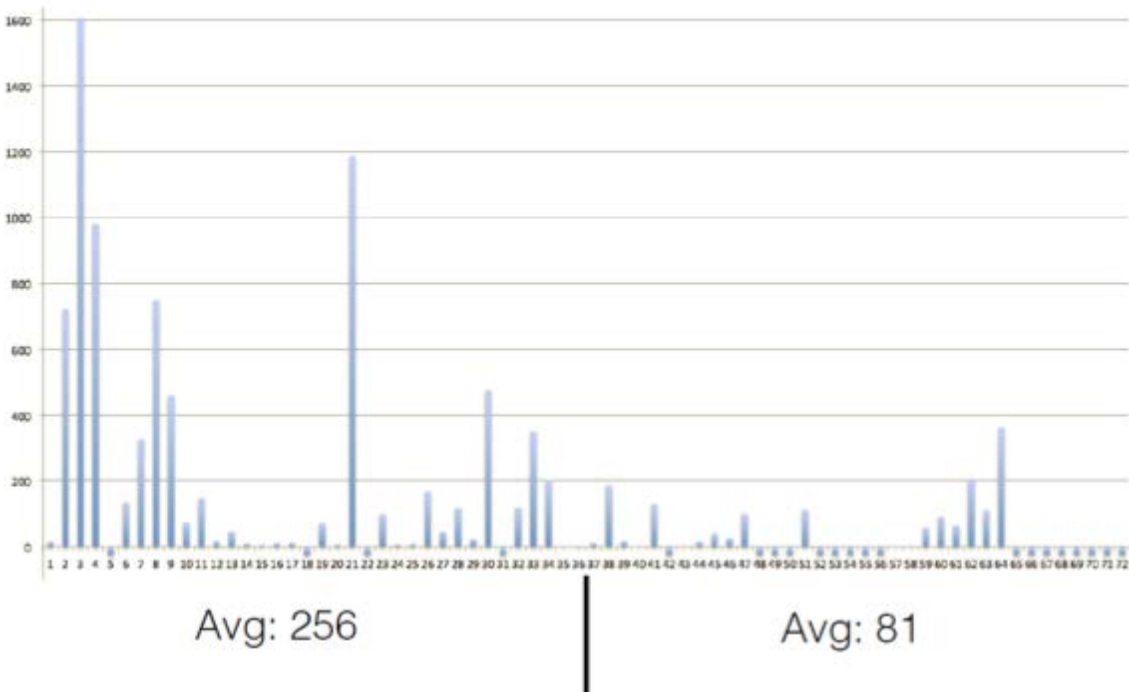
### Associate - Google Scholar Cites



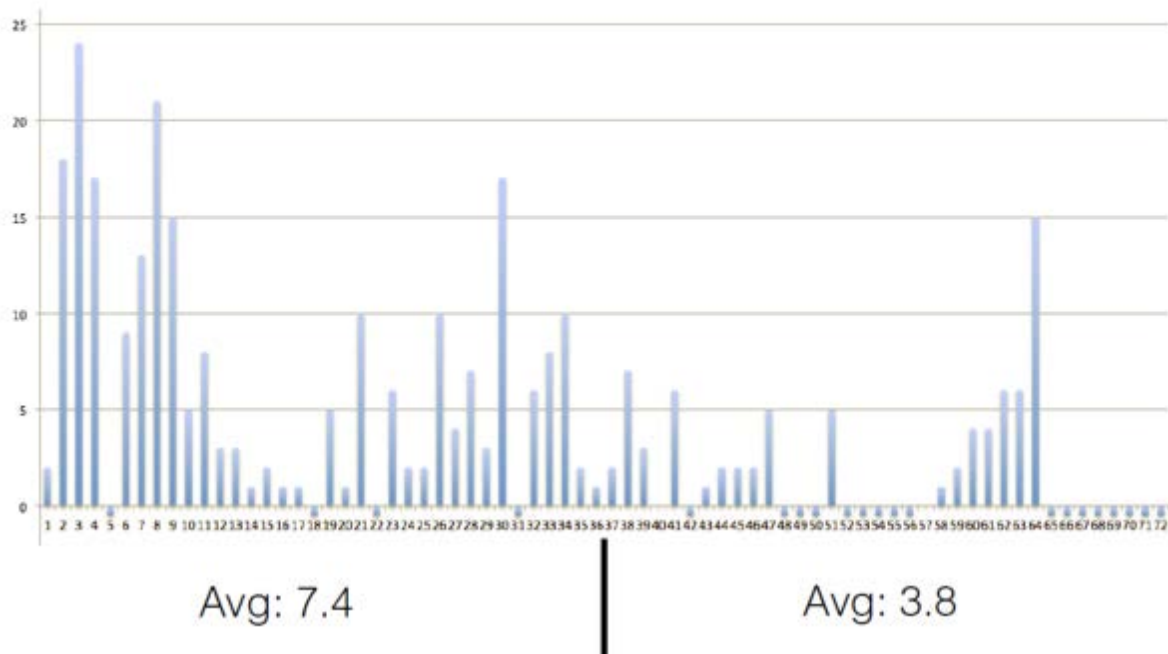
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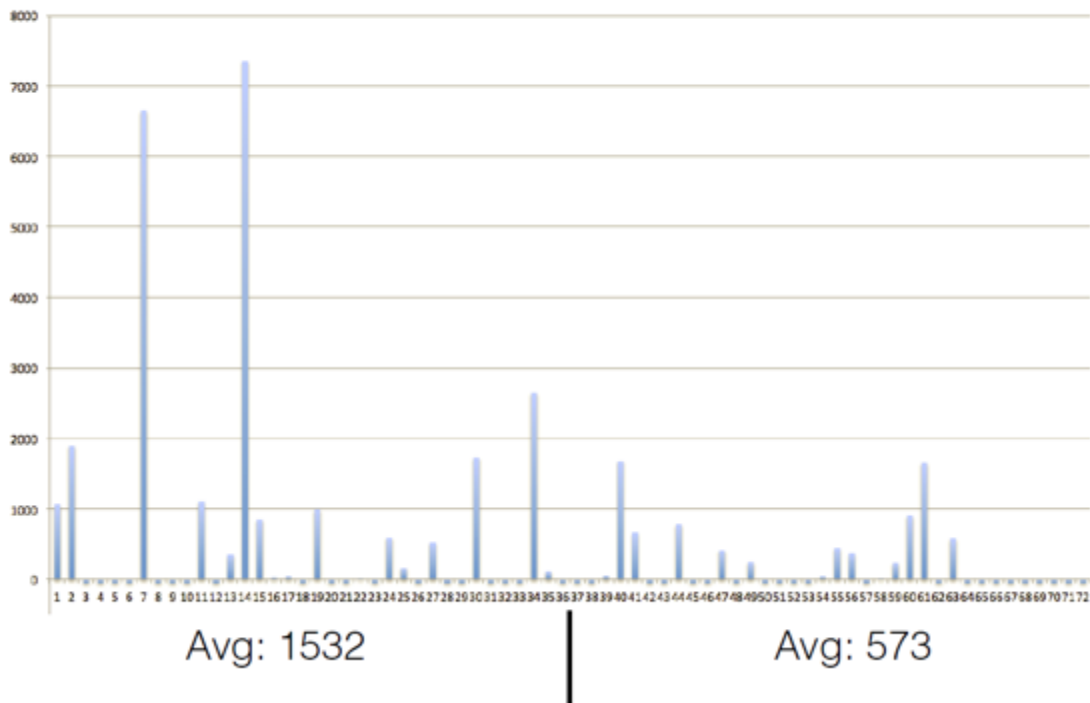
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## Associate - Web of Science h-index

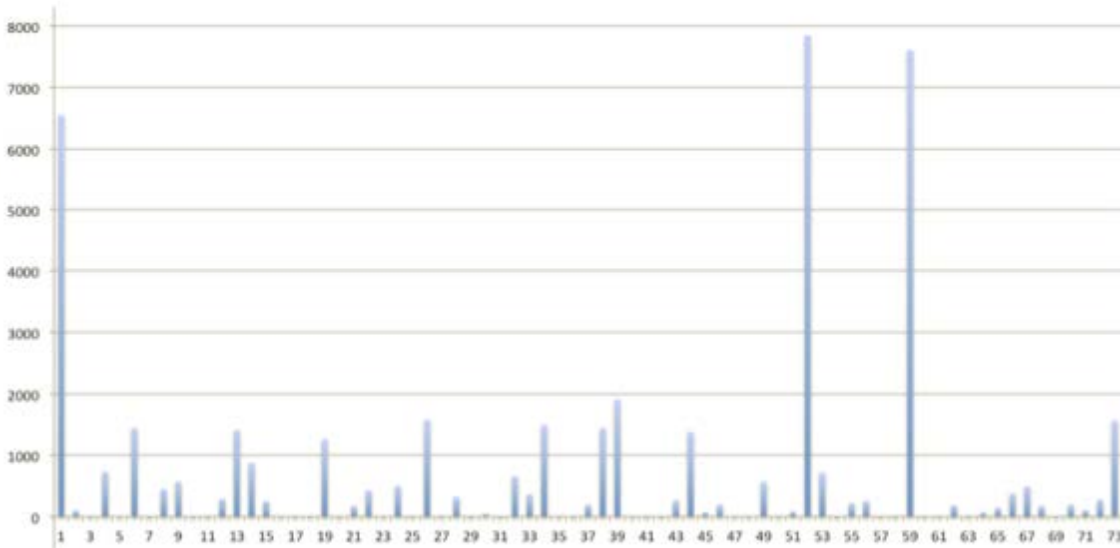


## Associate - Research Gate Citations



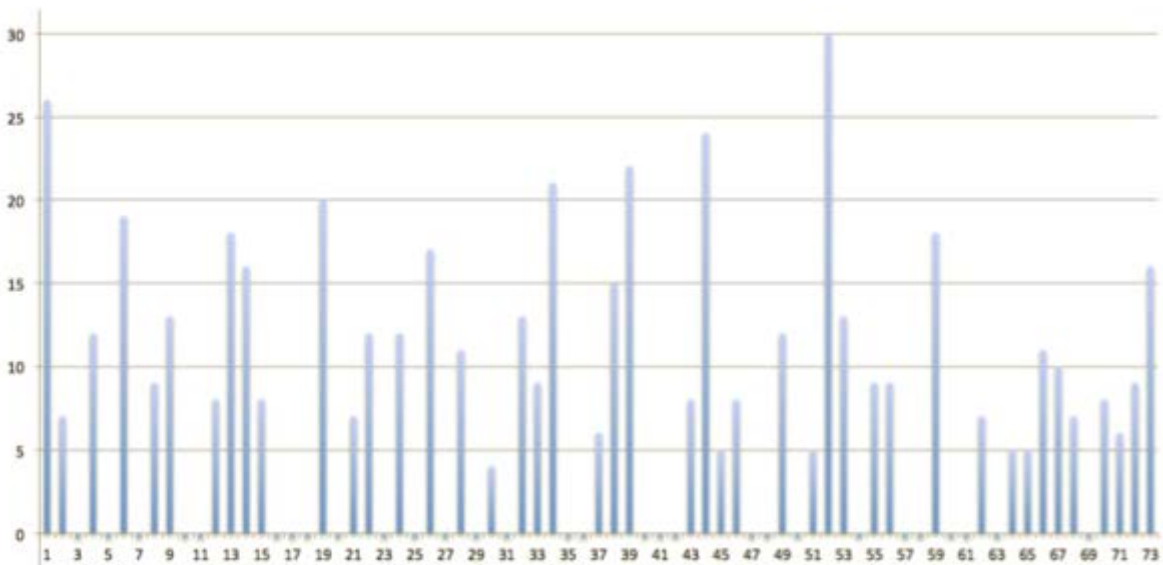
# A4: Assistant Research Impact

## Assistant - Google Scholar Cites



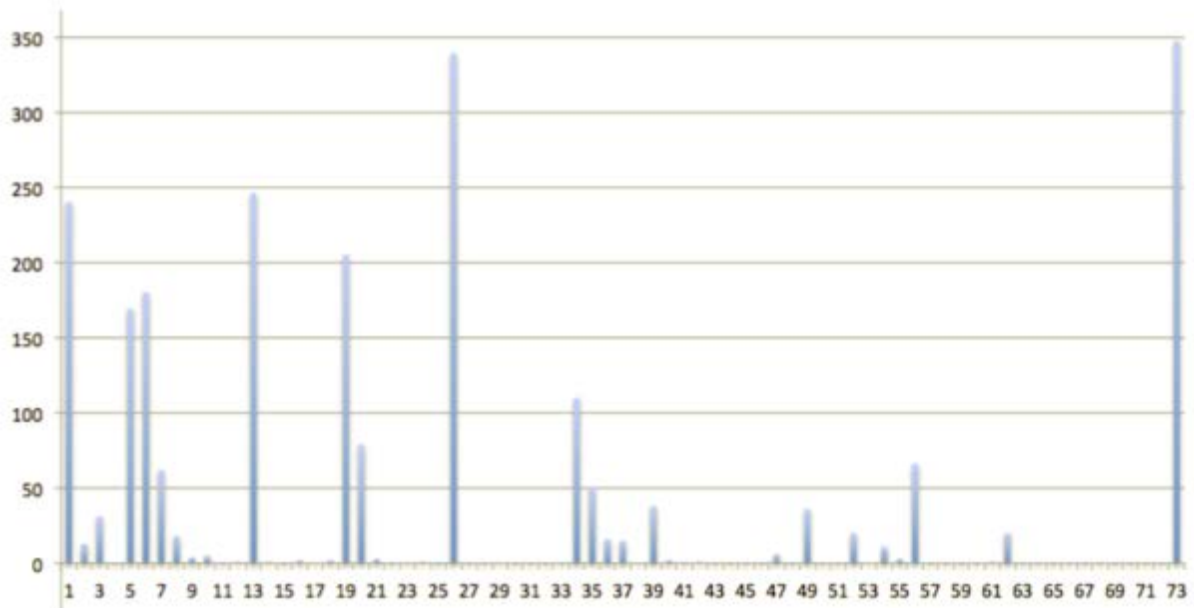
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## Assistant - Google Scholar h-index



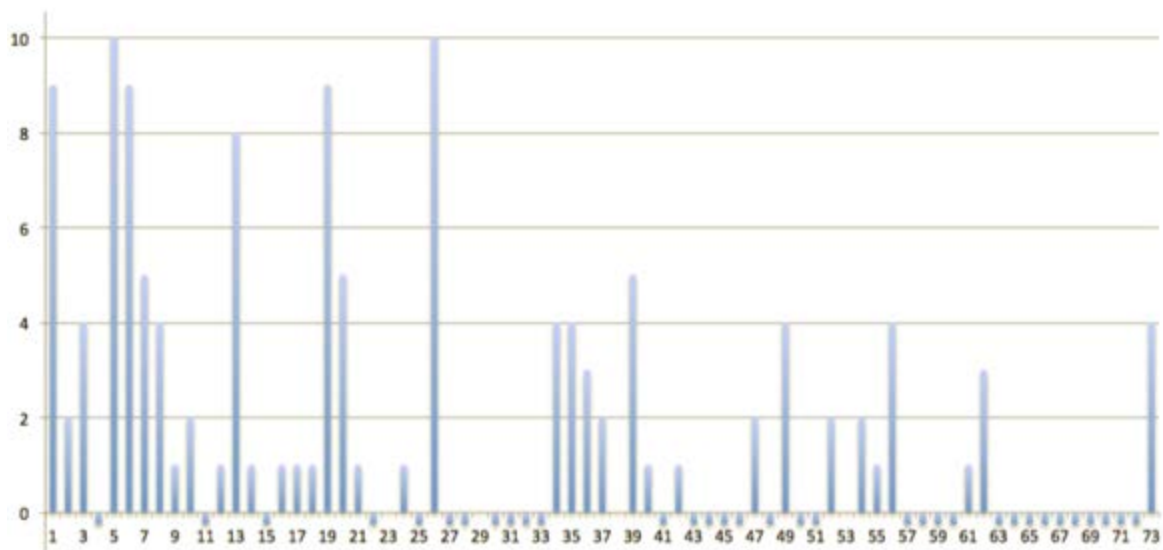
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## Assistant - Web of Science Citations



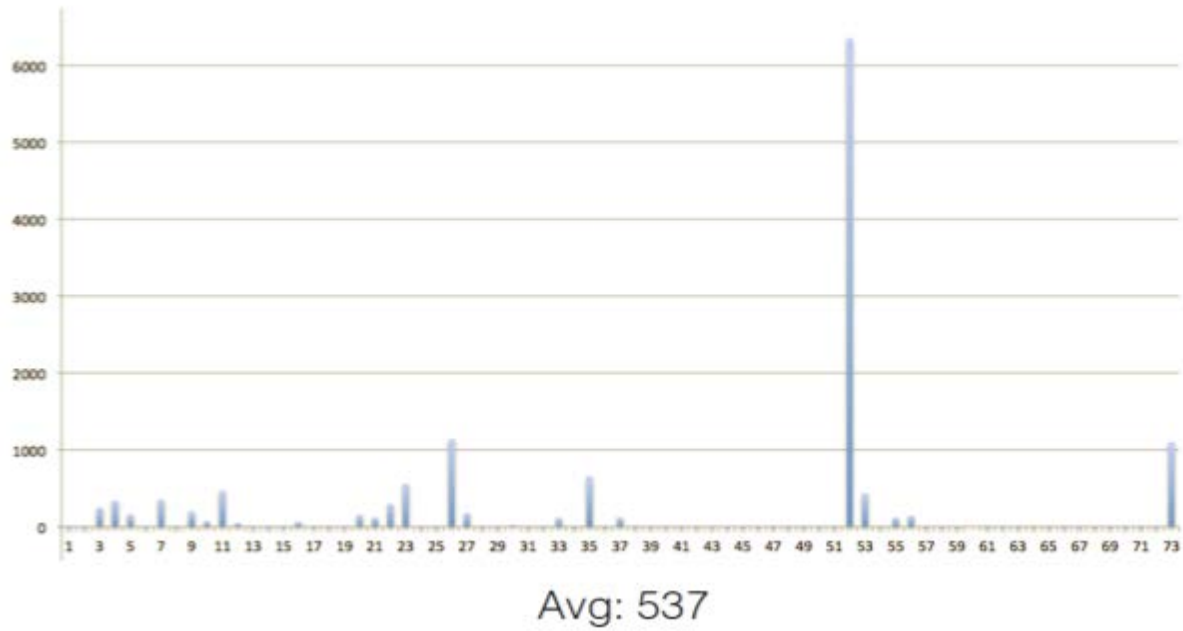
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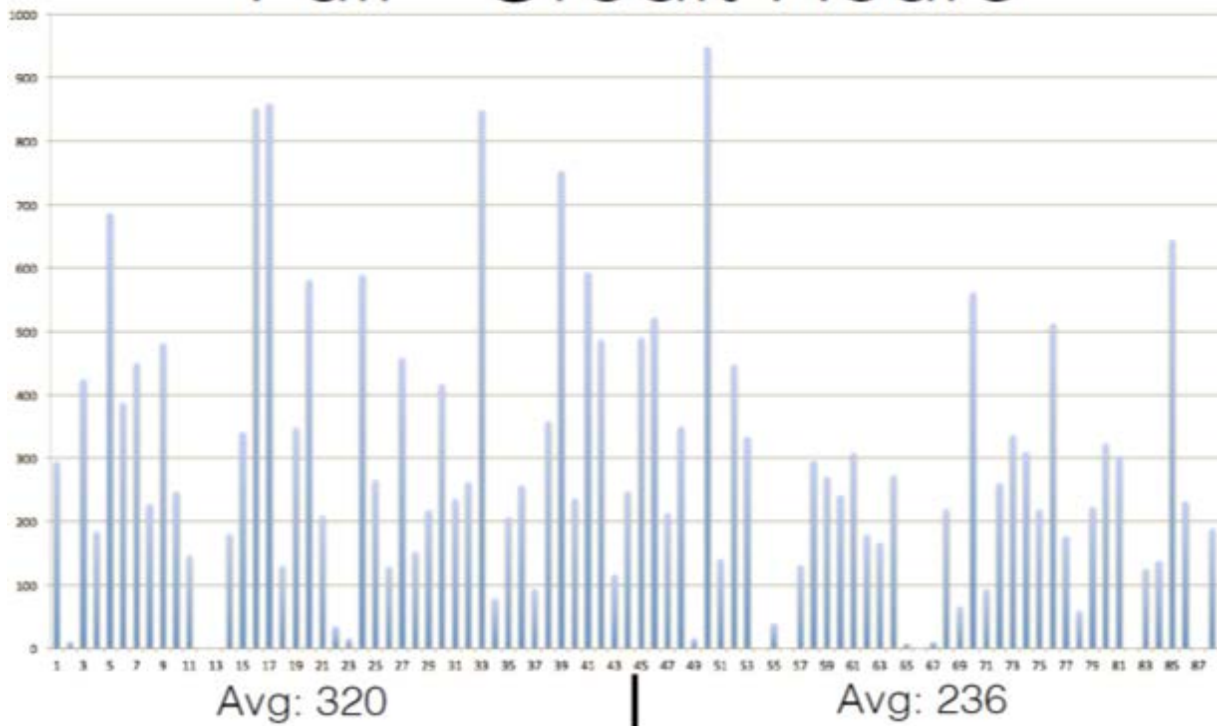
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## Assistant - Research Gate Citations

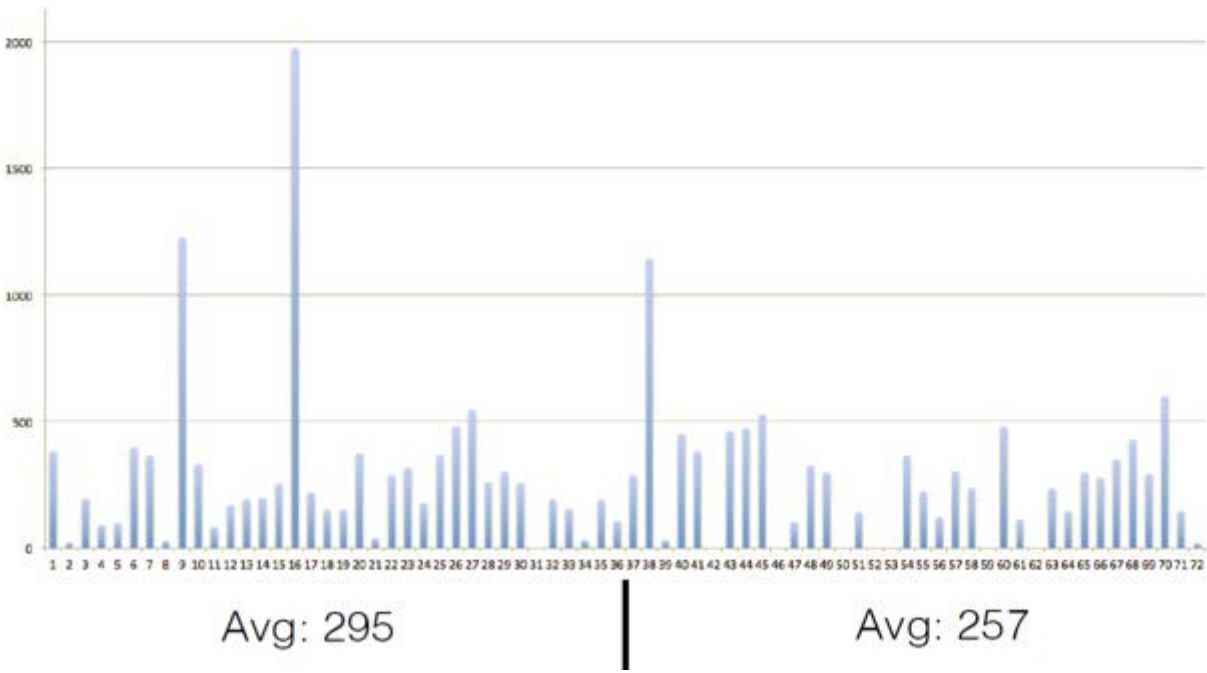


## A5: Credit Hours

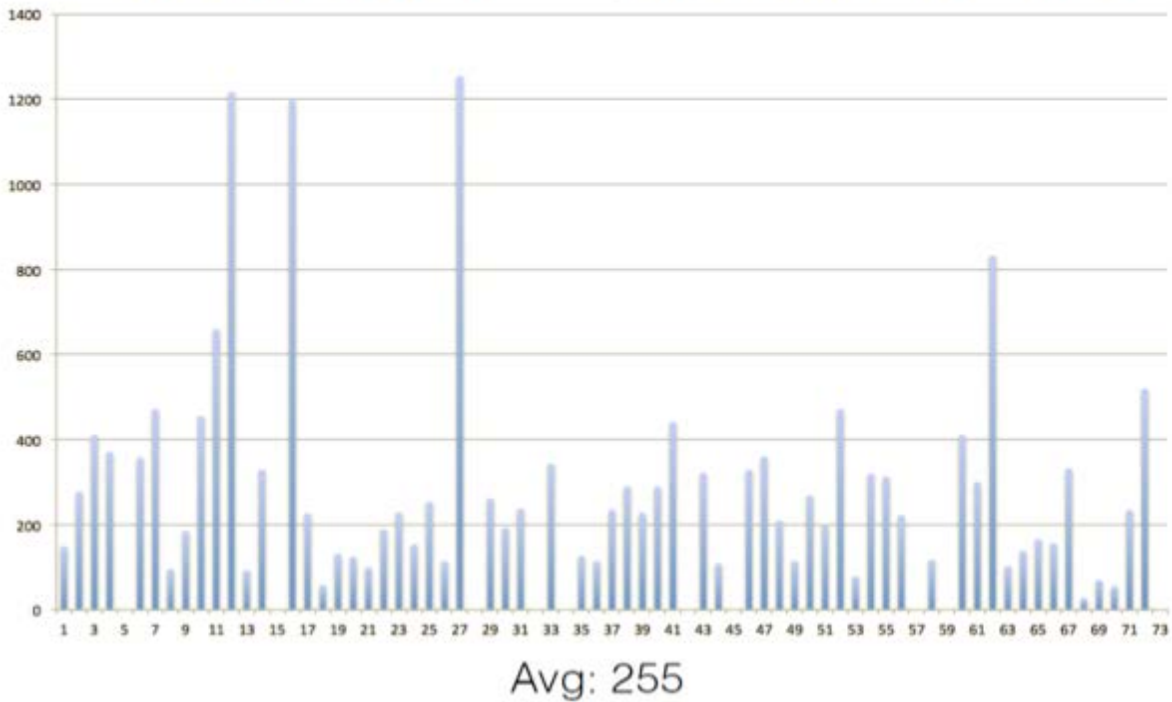
### Full - Credit Hours



# Associate - Credit Hours



# Assistant - Credit Hours





**A6: Table 1**

<b>Criteria (external resource generation* and Ph.D. student mentoring)</b>	<b>Base Instructional Load Target Per Year** before Buy-Out or Adjustment for Leadership Contribution</b>
<b>All Faculty (tenured, tenure-track, teaching)</b>	
<\$25K and 1 or fewer externally funded Ph.D. students	720 SCH
\$25K - \$100K and 1 - 3 externally funded Ph.D. students	540 SCH
\$100K - \$200K and 2 - 4 externally funded Ph.D. students	360 SCH
\$200K - \$400K and 4 or more externally funded Ph.D. students	270 SCH
>\$400K and 4 or more externally funded Ph.D. students	180 SCH
<b>Tenure-Track Faculty</b>	
0 – 2 Years	180 SCH (or two courses)
2 – 5 Years	270 SCH (or three courses)

\* - funding can be from external grants, gifts, royalties, etc.

\*\* - exclusive of graduate research, dissertation, thesis, and independent study hours

**Comments:**

- For reference, one 3-credit hour class with 30 students = 90 SCH
- Courses taught with fewer than 18 SCH (on average 6 students) are not to be counted towards instructional load.
- Buy-out cost may be unit specific, but cannot be less than 15% AY salary per course buy-out. All buy-out to be approved at the discretion of the department chair and dean. Faculty may not independently contract substitute instructors for their courses.
- Faculty should be teaching at least one course per year, unless there is a compelling reason for a waiver from this requirement (i.e., strategic major proposal development or other special assignments).

**Adjustment for Leadership Contribution:**

- Unit leader annual instructional load expectation is negotiated with their dean’s office, after consideration of other expectations.
- Directors of recognized centers with >\$5M in cumulative annual expenditures, and associate department chairs with significant responsibilities (especially leading to accreditation review) should be treated as if they have 50% appointments, so the instructional load target in the table above should be divided by 2.
- Directors of recognized centers with \$2M - \$5M in annual expenditures will be granted the equivalent of a one-course buy-out.

## A 7: Document 1

### **Materials Science Energy Institute**

Similar to the potential water institute at Mines, a new Materials Science Energy Institute is coming into existence. As described below by Craig Taylor, establishing the infrastructure and collaborative relationships with NREL are underway.

**Executive summary:** Materials science at Mines is a core research strength of the campus and has garnered recognition at an international level. The Materials Science Energy Institute will leverage faculty expertise, joint facilities, campus financial support, and administrative support to strategically target large, multidisciplinary, research opportunities creating a sustainable funding model. To accomplish this, the *Institute* will drive strategic decisions such as the acquisition and support of the central infrastructure required to be competitive at the next level. In the process it will become one of the crown jewels of the campus.

**Recent Progress:** Major progress since the proposal submitted last semester (Fall 2015) includes (1) the development of a list of frequently asked questions (FAQ) on joint Mines/NREL appointments by Nancy Haegel (NREL), Mike Kaufman, and Craig Taylor and (2) initial description of the research “pillars” for a joint materials research institute between Mines and NREL (Nancy Haegel, Mowafak Al-Jassim, and Bill Tumas (NREL), John Poate, Mike Kaufman, Brian Gorman, and Craig Taylor). To date five major pillars have been identified:

1. Joint Mines/NREL multiscale characterization facility
2. Automated processing of materials and fabrication of devices ("roll to roll"), especially materials by design (batteries, membranes, PV, thermoelectric, etc.)
3. Energy storage (chemical, thermal, electro-thermal)
4. Membranes and catalysis, especially earth abundant elements
5. Energy analysis and policy

Planning for the first pillar is the furthest along. An LDRD has been awarded at NREL to initiate a new funding structure for interactions with industry, namely industrial use of joint Mines/NREL facilities. The first project involves research of interest to CoorsTek. The Mines leadership has agreed to participate by providing the student/postdoc support for this project. The next steps involve appropriate Mines faculty and NREL scientists meeting to identify the best ways to mitigate the barriers and inefficiencies we now face in collaborative facility use. And, critically important, a focused joint workshop to identify key players on both sides and see what the broader effort might look like will occur sometime during the spring semester of 2016. Similar meetings to flesh out the other four pillars are also in the planning stage.

Much needs to be done in the spring semester of 2016 for several reasons. First, the renewal application for (IRG's) must be identified before the end of the semester. The office of the VPRTT is heading up this effort. Second, the current REMRSEC Director will be in transitional retirement sometime in the summer, and the institution will need to determine how to proceed going forward with regard to the future of the administrative and technical personnel and the central facilities developed under the REMRSEC NSF grant with strong Mines support.

Other progress includes: (1) launching of a joint NREL/Mines distinguished Lectureship in Materials series this April 2016, (2) developing plans to increase the number of joint appointments both ways, (3) developing plans to create joint fellowships to recruit the best and the brightest grad students and postdocs, and (4) developing plans to make it easier for NREL staff to teach courses at Mines.