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Regional Social Network to Promote and Support Underrepresented Minority Scientists

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REGIONAL SOCIAL NETWORK TO PROMOTE AND SUPPORT UNDERREPRESENTED MINORITY SCIENTISTS

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Abstract

Despite many well-intentioned efforts, underrepresentation of minority groups persists in the academic fields of science, technology, engineering and mathematics (STEM). Most of these programs have been too small to effect systemic change, though that is what we need to preserve the socioeconomic progress of the past several decades. We designed a new web-based tool to connect postdoctoral researchers and lecture organizers, enabling them to find each-other for talks, and, in the process, break barriers and level the playing field.

Authorship

Giuseppe Ciliotta, Greg Dracoulis, and Shaoming Feng all contributed to the research and writing of this report. The following is a breakdown of how the report was written for this project.

Giuseppe Ciliotta was responsible for selecting and culling references for the Background Research chapter, digesting them into a usable form, and presenting the relevant summaries to the group to incorporate into the report. He also assembled the site survey in Appendix B.

Greg Dracoulis was responsible for editing the paper for grammar, content, and flow, writing the abstract, Introduction, and Conclusion and Recommendations sections, formatting the paper properly, and synthesizing information to write the transitions between sections. He also put together the interview questions in Appendix A.

Shaoming Feng wrote much of the Methodology and Findings sections pertaining specifically to the design and construction of the old and new site, as well as the sections detailing technical issues our group encountered. He also put together the site layout as seen in Appendix C.

In addition to their individual roles and responsibilities, Giuseppe Ciliotta, Greg Dracoulis, and Shaoming Feng all prepared the references section and proofread the document as a group.

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Introduction

In Science, Technology, Engineering, and Math (STEM) fields, even now, white males continue to dominate across the spectrum from undergraduate admissions to bachelor's degrees awarded to Ph.D.'s and full professorships held (Brommer & Eisen, 2006). This situation was never a sustainable one, but it is becoming more and more precarious as the percentage of minority groups as part of the United States' population continues to climb. Today, when we desperately need new research-both basic and applied-to maintain our position as a world leader scientifically, economically, and intellectually, we are facing a brain drain the likes of which we have not seen before (Nelson, 2009). Chinese and Indian international students, for example, have been "reverse immigrating" back to their home countries in large numbers, taking their education elsewhere and slowly but surely helping to alter the international balance of power. In neglecting our own US-born minority citizens, we are neglecting a huge pool of talent that could be effectively mobilized to help close the gaps in our graying STEM workforce. This status quo perpetuates, if it does not exacerbate, a vicious cycle wherein minority groups are given insufficient opportunity and support to succeed at the highest levels of STEM fields, and as a result they tend to lose morale and enthusiasm (Brommer & Eisen, 2006). Younger generations of the same or similar ethnicity traveling through the academic "pipeline" see this trend reflected in the composition of the faculty as a whole, and thus have few, if any, mentors or role models to look to in their field. Even if such a figure is present, the student may see that mentor's job dissatisfaction as a symptom of the general institutional climate and deem his or her own

aspirations to succeed in that field too difficult or unrealistic to attain, eventually resulting in giving up on those aspirations entirely (Nelson & Brammer, 2010).

This "funneling effect" continues down the entire educational and career path, worsening at each successive step (Sasso, 2008). It is imperative that immediate steps be taken to lessen the impact of these hurdles and reduce the rate of attrition for suitable minority candidates as much as possible. We must strive to develop programs that quickly ramp up the number of minority candidates making the step from the post doctorate level to the faculty level, and that increase job satisfaction and morale once a candidate is placed in a faculty position. We must encourage the formation and development of strong social bonds, support systems, and networking opportunities for minorities across all levels (K-12, undergraduate, graduate, and postgraduate) to enable the United States to retain its position as a world scientific leader (Sasso, 2008). Current programs are too disaggregated to have any meaningful systemic effect, so we focused our project efforts on building an online tool that could be used regionally and, eventually, nationally or globally to connect postdoctoral researchers who need experience giving talks to conference organizers who need speakers. This search tool creates opportunity and forces those involved to search based on qualification instead of relying on their comparatively homogenous real-life social network.

Background Research

There are numerous different minority groups in society today, but it can be difficult to ascertain with any degree of accuracy what 'minority' does-or should-mean. To some, it could simply mean the races and ethnicities that are not included in the majority. To others, women too share the characteristics of a minority group and are classified as such. Yet another group defines minority status as a function of representation and opportunity in society, highlighting this by using the phrase "underrepresented minority," or URM. Embedded in each definition are various methodological and ideological assumptions that may obfuscate rather than clarify. In the discussion that follows, we try to tease out some of these complexities.

Underrepresented Minorities

The National Science Foundation and U.S. Census Bureau both break up race and ethnicity into seven categories: White, Black, Asian, American Indian/Alaskan Native, Hispanic, Native Hawaiian/Pacific Islander, and Mixed/Other (U.S Census Bureau). From the outset, this presents a problem—many studies and analyses conducted by other organizations use different categories, making comparisons between data sets very difficult, if not sometimes impossible. For different reasons, some studies include international students and others do not. Even those ethnicities lumped into similar categories (e.g. Asian and Pacific Islanders, in some cases) have widely varying characteristics, representation statistics, and needs. Some people may not want to identify themselves as part of a minority group, either to avoid discrimination or to avoid any appearance of preferential treatment, and others may not know explicitly which category they belong to and so may indicate

incorrectly. In one report, all respondents who indicated they were of "Mixed/Other" race were excluded from the dataset, reducing it by a full 7% (Nelson & Brammer, 2010). This can cause us to see a picture that is very different from reality.

Importance of Fellowships and Professorships

Underrepresentation has a huge impact on STEM fields. At the highest levels, this means less opportunity and less job satisfaction for minority groups. There are disproportionate numbers of white males in tenured faculty positions, and while minorities are underrepresented when it comes to teaching positions already, their representation weakens the farther up the academic ladder you go (Brommer & Eisen, 2006). The discrepancy is most glaring once you reach full professorship; many minority faculty are "stuck" at the level of associate professors. According to a recent analysis of minorities in science and engineering faculties in research universities by Nelson & Brammer, this perpetuates a cycle because minorities are less likely to enter or remain in STEM fields when they have few (or sometimes no) mentors or role models of their race or ethnic origin to encounter in their chosen department. Nelson and Brammer (2010, p. 4) point out that "if minority professors are not hired, treated fairly, and retained, minority students will perceive that they will experience the same" and that "this will not encourage them to persist in that discipline." This status quo can cause even the faculty members themselves to feel isolated or marginalized, especially since, as mentioned before, many are held at the lower ranks of academia and are not tenured. Without job security or critical mass (around 15-30% representation), most minority faculty members lack the ability or

leverage to change the environment within their discipline radically (Brommer & Eisen 2006). According to the report, it has also been anecdotally reported that subtly uncivil behaviors have a greater detrimental impact than overt acts of discrimination and that a hostile working environment remains a substantive concern for minorities in higher education (Brommer & Eisen, 2006).

A Strong STEM

The importance of STEM fields to society today cannot be understated, and failing to cultivate large, diverse pools of talent could have a profoundly detrimental impact. Although the stated goals of most science and technology research projects can initially seem esoteric and intangible, their implications can be wide reaching. One illustrative example of this can be found in, of all places, the Venusian atmosphere. In Carl Sagan's book, *Pale Blue Dot*, the author explains how a couple of scientists working on fundamental planetary research at UC Irvine along with NASA identified, by observing reactions involving chlorine and other halogens in the air on Venus, the dangers of CFCs (chlorofluorocarbons), which were widely used as refrigerants, propellants, and solvents (Sagan, 1997). These compounds, as it turns out, have the potential to destroy our atmosphere here on Earth, and we would still be using them today if those researchers had not been pursuing their interests. Our computers, cell phones, and video games all run thanks to thousands of years of pure mathematical research that, on the surface, had no practical applications. Chaos theory research helps us better understand and be able to predict the weather and disasters like tornadoes or hurricanes, and particle acceleration research may one day enable us to harness cheap, nearly limitless sources of energy.

This research really does need the support of all of us, and it needs as many people involved as possible. We simply cannot afford to let underrepresentation get in the way.

Race and STEM

To ensure the U.S. remains competitive in science, technology, engineering, mathematics, and research, we must increase the level of minorities who pursue postsecondary education in these fields. A new report by the National Academies, "Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads" highlights the fact that as late as 2006, African Americans, Hispanics and Native Americans comprised little more than 9 percent of Americans who held jobs in STEM fields. For these groups to be fairly represented, that statistic would have to triple. In an analysis published in the US Census Bureau webpage, Jennifer M. Ortman and Christine E. Guarneri state that "the Hispanic population is still projected to more than double between 2000 and 2050, while the size of the Asian population is projected to increase by 79 percent. Most race groups are projected to experience a moderate increase in size over the next four decades for all projection series." In order for the United States to maintain the global leadership and competitiveness it currently enjoys in science and technology, it must invest in research, encourage innovation, and grow a strong, talented, and connected national science and technology workforce. All of this is critical to maintaining national security and achieving the country's socioeconomic goals, and diversity plays a little-noticed, but very important role in this. Without minorities participating at higher levels in these fields, a huge pool of talent is being put to

waste. According to the Bureau of Labor Statistics, the U.S. labor market is projected to grow faster in science and engineering than in any other sector in the coming years, making minority participation paramount. Historically, there has been a strong connection between increased educational attainment and the growth and global leadership of the U.S. economy; if this position is to be maintained, the STEM pipeline must reflect and adapt to changing demographics across the country (National Academy of Sciences et al., 2011). "The pipeline can be defined as the process moving young scientists from their undergraduate bachelor's degree to Ph.D. programs to postdoctoral fellowships to faculty positions" (Brommer & Eisen, 2006, p. 35). Many grand challenges still await engineering solutions, and the more minds we have working on these problems, the better our chances of solving them become. Race, creed, gender, and sexual orientation are not things that affect problem-solving ability, so we should work to remove any barriers in preparation, access and motivation, affordability, and academic and social integration between and among these groups (Brommer & Eisen, 2006).

African Americans and the Funneling Effect

An article in *Science* magazine points out that a STEM education does not offer a good return on investment for minority students who may be looking for a quick, easy route to a major, stable shift in their quality of life (Sasso, 2008). The sciences can be perceived as too difficult and the payoff as too uncertain or far in the future, and this coupled with the massive debt load incurred by college education can be a factor encouraging attrition from the field or from college altogether. According to a study conducted in 1998 by Nellie Mae, the largest nonprofit

provider of federal and private education loan funds in the US, “69 percent of African Americans who enrolled in college but did not finish said that they left college because of high student loan debt as opposed to 43 percent of white students who cited the same reason” (Journal of Blacks in Higher Education, 2007). African Americans in particular specify an intention to major in a science, technology, engineering, or mathematics related field in larger percentages than even their white counterparts (Sasso, 2008). However, attrition rates for blacks are much higher than for those same white counterparts. While attrition rates are high for African Americans across the board, they appear to be especially high in areas related to science or engineering and the reasons for this are not well understood. Many minority students may see a lot of math in high school (enough to generate interest perhaps), but their level of exposure and their habits may not serve as sufficient preparation for the "rigors of the college curriculum" (Sasso, 2008). This leads to the idea that educational disadvantages are cumulative in nature and end up forming a "funnel" through the levels of education. As minorities progress through the “academic pipeline,” their representation progressively worsens—at undergraduate admissions, the playing field appears the most even, but this is only temporary. When degree attainment in STEM fields is looked at, representation figures become decidedly askew once again. Underrepresented minority representation in doctorate degree attainment drops from even that in BS attainment by a factor of 2 or 3 (Sasso, 2008). This is a powerful affirmation of the funnel effect, but also shows that more efforts and programs should be directed at strengthening the 'pipeline' at this particular transition. Non-minority students are

impacted by the absence of minority faculty, too, as they are deprived of an education diverse in thought and ideas that result from the interaction of faculty diverse in background and culture. It is not just the minorities who are victims here (Sasso, 2008).

Effect of the Term URM

One noticeable trend in the literature has been the use of the term "underrepresented minority" or URM. This encompasses those of minority status whose percentage representation in a certain field is less than their percentage representation in the general population, so it seems as though this would be a good answer to this problem (Nelson & Brammer, 2010). However, the use of this term still does some groups a disservice. For example, Asians are not considered URMs in this sense. Asians have reached critical mass at every faculty rank in many of the sciences, which might lead one to believe that Asian American students have a good set of same-race mentors or role models, but this can be misleading. Up to ninety percent of the Asian hiring pool for faculty positions consists of foreign nationals who had not previously even obtained their BS degrees in the U.S. When only Asian Americans who obtained at least their BS in the U.S. were considered, their representation among faculty was much closer to that found in the general population, and in some disciplines they were even, indeed, underrepresented (Nelson & Brammer, 2010). This is important because the life experience and fluency of U.S. born Asian Americans is something unique to be cherished and protected.

Asian Dilemma

The exclusion of Asians from minority and underrepresented status is a bigger problem than just this, though. It reflects a pair of stereotypes that isolates the group in a very specific way and ostracizes them from both minorities and non-minorities. Lee (2006) makes the case that there are two prime stereotypes used to perpetuate the subjugation of minorities (including Asians themselves) and ensure white dominance. These two types are the "yellow peril" foreigner (YPF) and the model minority (MM). The YPF view rehashes the standard rhetoric regarding immigrants, such as the threat of erosion of white dominance, "taking over" our schools, and simply the specter of foreign- or other-ness. The MM view seems to be the polar opposite, lauding Asians for having overcome the obstacles of being a minority through hard work and family values, thus rendering them disenfranchised from minority benefits because they do not "need" them (Lee, 2006). However, this does not take into account the diversity of citizenship among those of Asian descent (e.g. Pacific Islanders, who still deserve support and Singaporeans or Japanese, who are today first-world societies) and so it unfairly handicaps those who still are disadvantaged but also happen to be Asian. At the same time, this also is used as a benchmark to hold over other minorities' heads in such a manner to imply they should have been able to achieve such success on their own. However, the paper posits there is a continuum between MM and YPF schools of thought; push the characteristics of the model minority to a rhetorical extreme and you have the yellow peril foreigner: "to be hard working is to be unfairly competitive, [...] to be law-abiding is to be rigidly rule-bound" (Lee, 2006). This produces a sort of "racial

triangulation" through simultaneous relative valorization (with regard to other minorities) and ostracism, which still ends up resulting in said ostracism and Asians being pigeonholed into a non-minority minority third place where they are continually marginalized but do not receive any minority benefits (Lee, 2006).

What Is Currently Being Done

There are a wide variety of programs developed to advance minorities in STEM fields, but at the same time, each program tends to only impact specific segments of the scientist "pipeline" from K-12 to Ph.D. One report by Brommer and Eisen (2006) identifies the lack of proportionate increases at the levels of post doctorates and faculty as breaks in that pipeline, which sets up a platform for their model to exist on. The report goes on to talk about the importance of fellowships to post doctorates and the number of post doctorates who are, in fact, not participating in these fellowships when now, apparently, at least one such experience is expected and almost required of faculty or research candidates at that level (Brommer & Eisen, 2006). Many other models of programs developed to equalize representation exist and have been successful, but they are too few, too specialized, and too far between. Most of these programs cater to less than a dozen people a year at a select few universities. They do set out ways and means to help, though, and so are still quite valuable. For example, in Brommer and Eisen's model, teaching experience, support and networking, and a mentorship program are all important aspects that have been identified as ways to start narrowing representation gaps. Lack of preparation and the usually asocial nature of postdoctoral fellowships are targeted as problems which should be addressed, and the opportunity to speak, network, and

receive feedback afforded by something like a monthly seminar series among some sort of organization or network is brought up. The authors also point out the importance of continuing education regarding cutting edge methods of "how to teach" as well as of information or support with respect to grant writing, faculty interaction, etc. (Brommer & Eisen, 2006).

Justification for a Social Network

We hope that creating a social network or social tool will level the playing field between underrepresented minorities and overrepresented groups by increasing opportunity across the board, allowing for those in underrepresented groups to get more involved and increase their qualifications and experience, giving them greater confidence and helping them improve their speaking skills by giving more presentations. We also hope that blind networking through the site will happen, regardless of race, creed, gender, or other identifiers. According to a report written by Bramoullé and Rogers (2010), searches based in an online networking tool such as the one we hope to build tend to reduce homophily, or “love of the same,” our tendency to gravitate towards linking with people similar to us. According to their paper, “this mechanism is not obvious a priori, given the presumption that social segregation may be aggravated by network effects. Yet it has an intuitive explanation. Even if meetings across groups are relatively rare, a new individual still meets some individuals from the other group. Through them, he then has access to many additional individuals from the other group, and so diversity among friends of friends is greater than among friends. We believe that this captures an important mechanism at work in real networks […]” (Bramoullé &

Rogers, 2010). We hope to exploit this in our network to achieve our goal of supporting and encouraging the participation of underrepresented minorities in STEM fields.

Methodology

The goal of our project was to develop a social network to break down walls and level the playing field by allowing students, post doctorates, faculty, and researchers to develop close ties. While it would be intuitive to assume that random networks with many weaker ties would transmit information much faster since there would be many more opportunities for the information to make long "jumps" very quickly, this is not the case. When the idea or behavior to be transmitted becomes sufficiently complex (even something as complex as "get more involved in science"), highly clustered networks tend to be more efficient at encouraging the adoption of said idea or behavior. The larger numbers of close ties exert signals and thus increase pressure towards or at least exposure to the idea or behavior, making the very same seem more and more feasible or palatable (Centola, 2010). To construct such a network, we had to develop a technical plan, a marketing and outreach plan, and a rough design of how our online presence should be laid out.

Initial Ideas

Based on our literature review and conversations with our advisors, postdoctoral researchers, and other faculty, we identified several possible avenues through which we could begin attacking the problem. It became clear to us that a platform for scientists and researchers to organize and share lectures (along with mixers or networking dinners perhaps) would be beneficial to postdoctoral researchers by allowing them to get more exposure and experience in speaking publicly about their work. We also saw that job and fellowship finders (which could help navigate the currently disaggregated landscape) and other resources such as

editable repositories of tips and short primers on what is necessary to succeed in a science career, how to teach, how to write a grant, etc. could be useful as well, as they have been successful in the past. Finally, we saw that mentorships connecting scientists to their community could be a helpful part of, or at least an interesting tie-in to, this network, since this might engage researchers socially in a positive way and promote awareness and participation in the general population, targeting lower levels of the "pipeline."

Where to Start

At the beginning of our project, we planned to make a small, focused model website with one main function, and continue developing it gradually. After some discussion, we decided to first implement a social networking website to help postdoctoral researchers show their work and communicate with each other in a supportive environment. As we started building the site, we interviewed several postdoctoral researchers at WPI in order to determine what functions this site should focus on, asking them a series of questions about their current and past behaviors (e.g. social networking usage, conference and seminar attendance, etc.), personal preferences, and what they would like to see from a new website that would hope to cater to their unmet professional needs (see sample questions in Appendix A). We also looked at a range of other websites, including popular social networking sites such as Facebook and LinkedIn as well as more focused websites with a target audience similar to ours who could be considered "competitors" in an entrepreneurial sense, in order to ascertain what features they offered and how we

could differentiate ourselves by identifying and filling what we came to call "gulfs in service."

How to Start

We realized from the inception of this project that we would have to employ a set of dynamic, server-side technologies in order to achieve our goals. A dynamic site is one where the content of pages changes based on user input, like login information or queries to a search form that are delivered to the server. This is in contrast to a static web page, where the web developer fixes all the content at the time the page is built. Confusingly, the term dynamic also refers to pages that use effects like rollovers (images or zones that change appearance when the user hovers his or her pointer over them) and other animations like panels that slide open and closed to reveal or hide content, though these types of pages are distinctly different since all the processing still takes place in the browser on the user's computer-also known as the client (Powers 2010). Since we wanted to deliver individualized profiles and tools, we had to use server side programming, but then we had to determine which language to use.

There are several candidates to consider when choosing a server side technology, but we set on PHP early on mostly because it was the language both the programmers on our team knew, and because it was a widely supported language that could be easily used on both Windows and Unix/Linux systems, easing shared development and making the code more portable. We also considered Django and Ruby on Rails, eschewing use of ASP, JSP, and ColdFusion due to their increased complexity and the resultant deployment concerns (as these are less common

technologies, it is more difficult to find hosts to deploy to and those services are often more expensive). We determined Django to be less useful for our purposes due to its optimization for back-end created content vs. user-created content, and Ruby on Rails was discounted—even though it had many advantages over PHP in the context of social network creation—because of its relatively recent fragmentation issues with respect to best-practice server and database choices (Kashuba, 2008) and potential difficulties in deployment because of this.

Our team then decided to pick a domain name and deploy to a single computer located in our advisor's office, with the option to upgrade to remote hosting on a dedicated web hosting provider's servers. Initially, we thought this would be a good plan because the computer was surplus equipment and thus free for our use, and because we believed it would be easier to configure owing to our ability to have both physical and root user access to it. We set up a relatively standard LAMP (Linux, Apache, MySQL, and PHP) stack on the unit we were provided, installing Fedora Core as the operating system because of its free nature, past positive experiences with it, and compatibility with a wider range of hardware than Linux distributions often considered for such tasks (e.g. Ubuntu), and we set up a deployment system using WPI's Subversion servers for version control since more than one programmer might be working on the project simultaneously.

After we made these technical choices, we moved on to developing a logical and conceptual model for our site. It was important for us to consider the requirements of our site, however we may deviate from them, in order to develop an idea of what we needed to create before actually creating it (Westfall, 2006).

Otherwise, we could put in a great deal of work designing exactly the wrong system (Wiegers, 2004). The requirements we initially developed are detailed throughout the rest of this chapter.

Users

Before we started major work, we had to put thought into how to develop a recruitment protocol. Users are always one of the most important parts of a social networking website. First, we planned to introduce our website at WPI through the Office of Diversity Programs, department heads, faculty, and the Office of Graduate Studies and Enrollment. We planned to leverage our network here at WPI for our initial user pool when testing our website and after we have finished it. We decided that once we determined which course of action with regard to user discovery and recruitment proved the most successful, we would reach out in a similar manner to the people in analogous structures and positions at nearby institutions to include the University of Connecticut, the University of Massachusetts, Northeastern University, Harvard University, and others through personal and professional connections. We also set on building groups across other social networking domains (i.e. Facebook) and reaching out to professional societies and foundations like the National Science Foundation (NSF), the Institute of Electrical and Electronics Engineers (IEEE), and the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) to introduce our project and website and attract potential users from there. Finally, we planned to set up a "viral" user recruiting tool, which would let users send out a limited number of invitations to their close

research associates (perhaps a postdoctoral researcher's PI or department head, or a faculty member's sponsored researcher).

Surveys

As part of building our site, we wanted to solicit feedback and opinions from our users to ascertain what their wants, needs, and points of friction with regard to our service are. We also planned to use these surveys to collect demographic information, to include ethnic background as well as nationality, which, coupled with the other information we will have already obtained, would have allowed us to start tracking these statistics by institution, location, and field.

We also planned to release at least one more subjective survey to gain insight with regard to attitudes and feelings concerning social interactions, minority or underrepresented status, and success in a STEM field, as well as to seek out advice and traits that may have helped those of underrepresented minority status persist in their field to the level of postdoctoral researcher. A link to these surveys would be displayed on a user's home screen after he or she logged in, and from there they would be taken to the consent form and on to the survey if they chose to continue. The surveys would be strictly opt-in, and a user could choose to ignore a survey invitation at any time and the notification will be suppressed. We would endeavor to make sure users know they are not required to participate, that there would be no penalty for not doing so, and that they would be able to withdraw their participation and erase their responses at any time they chose before completion.

Portfolios

Allowing users to post portfolios including their curriculum vitae, the products of their research, a history of their lectures, and any honors or awards they have received would be a major portion of the site that we hoped would attract a large number of users to come onboard. Postdoctoral researchers would be able to post or link to their published papers on the site, and these would be browsable by field, popularity, and rating. The most popular and highly rated papers on the site would be viewable on the front page for the public to see, as would be a calendar of upcoming lecture events in the user's area. Papers and lectures would all link back to a user's portfolio, where an interested faculty member, department head, postdoctoral researcher, or any other potential colleague or employer on the network could find the rest of that user's information and portfolio if they were interested.

Users would also be able to invite other users, based upon their portfolio, to come lecture at their home institution, either offline or online. This would be recorded in our database and posted in the invited user's lecture history and on the site calendar if made public. This, we hoped, would allow postdoctoral researchers, faculty, and department heads from different institutions to connect and network in real life, not just online. Most of the portfolio would be publicly accessible by a short URL (such as www.example.com/user_name) so researchers could share their portfolio with people outside the network as well, and hopefully this would garner that person's interest enough to get them thinking about joining our network as well as a byproduct.

Groups

User of our site would be able to set up groups in a certain area for users with the same interest to discuss topics relevant to them. We planned for this to provide a very convenient forum for the exchange of ideas. After a group is set up and some users have been invited, one would also be able to post an invited lecture to a group or poll the group to see if anyone would be interested in coming to give a lecture. To facilitate communication within the group, there would be a comments board and a list of all members. Groups would be able to be public or private, and the founder of the group would be the administrator and would be able to change privacy settings as well as give some rights to other member of the groups. On each group page, there would be a news feed which would show the activity of the group members as well as relevant events.

Friends and Messages

To communicate with others better, a user would be able to invite other users as colleagues, in a manner similar to "friending" on Facebook. Users would be able to see their colleagues' activities, like posting papers or accepting invited lectures. Also, a user would be able to send messages to their colleagues or other members of the website.

Findings

As with any project, we encountered a number of difficulties and pieces of new information that changed our course throughout the phases of development of our site.

Starting Too Fast

In our haste to start developing our website, we made several grave, textbook errors. Our team did not commit enough time and thought to the task of requirements generation, and we started development of the website before the requirements were fully completed. This is understandable, in context, as we were under the same time pressure that is common in commercial software development projects—we set deadlines and timelines focused on implementation and a finished product, but these, too were laid down without fully considering the requirements. We also got set on generating the requirements ourselves and began development of the website without consulting members of our target audience—the users and real stakeholders—resulting in further miscalculations and gaps in our design. Because of this, we fell prey to an increased level of requirements 'churn.' This refers to changes in requirements after they are initially agreed to and base-lined (Westfall, 2006).

Some of this change is a part of a refined understanding on our part as we continued to develop the website, and changes also occur because of changes in the environment or the users' needs over time. However, we were unaware of the environment as well since we did not research other websites in the same sphere of service and competition until late in our development cycle. In addition, since the

requirements were poorly defined from the outset, we experienced requirements churn because of missing requirements that should have been included in the original specification and because of ambiguity in the requirements that already existed. Changes to and errors in requirements account for 70 percent to 85 percent of the rework time on an average software project (Wiegers, 2003). If one finds a requirements error during the requirements phase and it takes one unit of time to fix, the time to fix that same defect will typically increase as it is found later in the life cycle of the project. Studies show that it can take up to 100 times longer to fix a requirements defect if it is not found until after the software is released (Westfall, 2006). This caused us a number of problems, and cost us a great deal of time, though any software engineering project of a sufficient size can fall prey to the same if it is not carefully and meticulously managed by all those involved. Fredrick Brooks, in one of his seminal works, said "The hardest part of building a software system is deciding precisely what to build. No other part of the conceptual work is as difficult as establishing the detailed technical requirements, including all of the interfaces to people, to machines, and to other software systems. No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later" (Brooks 1987, p. 13).

Site Survey

Upon reviewing the environment of competition and already-existing services similar to ours, we realized that a social networking focused website for researchers (ResearchGate.net) had already been developed and publicly released, as had a service focused on tracking and sharing scientific publications in a social

manner (Academia.edu). This was a definite setback, as these were all core features of the site we had wanted to create. Though this revelation most certainly lowered our morale, it had a positive effect on our project because it forced us to return to the requirements engineering phase for enough time to realize we needed to actually start the process of interviewing potential users and stakeholders. You can find the further results of our site survey in Appendix B.

Problems Finding Users

Our initial protocol of trying to find users resulted in a number of dead-ends. As we soon realized, it is more difficult finding and getting in touch with postdoctoral researchers than we initially thought. Many institutions do not have a single, consolidated list of the people doing research in their labs, and the one university that did have such a list could not share it with us because of privacy policies. Most of the organizations we reached out to, like the Office of Diversity Programs at WPI, were unable to help us for these same reasons. It seems we would be doing something novel if we assembled a list or directory of postdoctoral researchers at each institution. At WPI, the difficulty locating researchers was exacerbated by the fact that we are a small institution with fewer researchers in comparison to many of the larger universities and technical schools in the area. Though this certainly made our work more difficult, we were finally able to get in touch with a few researchers at our campus through our advisor's personal connections.

Interviews

We then set out to interview the researchers we were introduced to. The interview questions we prepared can be found in Appendix A. Although our sample

size was relatively small, the amount of information we gleaned from them was extremely helpful in making design decisions for our site. We found that even though the people we talked to all used their discipline's main society's website, they felt there was no single, good resource for information about career paths, or a single, large, aggregated "job board." While we knew there were resources for job searching online, we did not realize that many researchers may not be aware of them. We found it interesting that even the researchers themselves did not know of a single online resource to find tips or advice on how to progress professionally, and that they saw this as a problem.

We found that postdoctoral researchers know about ten to fifteen other researchers each, from previous and current work as well as their earlier academic career, and seem to use email to correspond most of the time. This informed our decisions by prompting us to use email addresses as login names and giving us the idea to try to keep as much correspondence as we could in email by allowing for replies to be processed and reflected on the site rather instead of requiring users to follow a link. We also used this information to prioritize contact import via email rather than through Facebook or any other resource. In fact, the researchers we spoke with seemed to indicate that they either did not have time to use Facebook on a regular basis, or even if they did, that they would not want it associated with their professional life. We had initially thought of allowing for logins through Facebook, but since these preferences were indicated so strongly, this caused us to rethink spending time on that idea.

The people we spoke to indicated that most researchers would love to be able to put themselves in a database where they could be searched and invited to give talks, since many are looking for opportunities to add to their curriculum vitae. Some of those we interviewed indicated they had a resume online already, but these people were the exception rather than the rule. Most just sent out their CVs by email when requested. The ones who had LinkedIn liked the way their resume creation tool worked since it was short and easy and only prompted for necessary information with few requirements, but felt that it did not target science very well. This seemed to us to indicate that a science-focused 'lecture bank' tool would be something that they would be able and want to use, but that we would have to make fast and easy to navigate and use. One thing we were told rather explicitly was that having abstracts up on the site would be good, since CVs traditionally only have titles and those are not always a good indicator of research content, and because abstracts and keywords could better summarize a talk someone could give. Finally, we learned from these interviews that postdoctoral researchers would like to see better networking facilities for use during conferences, lectures, symposia, etc. and that we should keep any surveys and questionnaires we sent out short and multiple choice since longer surveys with any sort of long form questions would be often ignored because of time and interest constraints.

Technical Difficulties

At the same time we were conducting these interviews, we were also encountering problems with the site we had begun developing. User logins, registration and forgot password emails, and file uploads all did not work. The

cookies we were setting to preserve login status across pages were being rejected by some modern browsers like Internet Explorer 8 because the domain name and the address issuing the cookie did not match; this was because we were using a frameset to point people who went to a URL (originally growstem.com) directly to the IP address of our standalone machine, and this looked like a security risk to the browser. Emails we were trying to send from the machine our site was located on using SMTP were being consistently marked as unsolicited "spam" emails because the IP address from which the messages were being sent did not match the domain records either. Finally, we could not get file uploads to work properly on the computer we were using because of file permissions issues—the files would upload to a directory on our host machine, but we could not read or move them once they were uploaded. The measures we tried to use to solve this problem, which included changing permissions so anyone could read, write, and execute files in certain directories, opened up unacceptable security risks for a public facing web server. These issues all became indicative of the problems with setting up and maintaining a server on our own: our uptime was reduced because of shutdowns and reboots we had to perform, the security configuration of the system was difficult to get right, and while we could likely have solved these technical problems we were having, the time it would take to research each issue and implement a fix was time that would take away from our actual coding of the site itself.

Conclusion and Recommendations

As the result of our site survey, the interviews we conducted, and the technical problems we began having with the site, we decided to start designing and building the website again from scratch (Appendix C details the changes in focus and organization of the site as a result of this). Instead of building a social network, we decided to pitch our site more as a tool, and we decided to make it very simple and targeted at first. We changed the name from GrowSTEM, which was rather vague and more in line with our previous, broader aims, to LectureBank, and we began focusing on lecture invitations and researcher portfolios instead of publication storage and networking. The most important components of this new site we identified were the aforementioned portfolio and lecturer search tool, an events and invitation system, and perhaps a wiki to be added later that would allow researchers to post career advice to other researchers as well as prospective candidates. We switched from using a single computer located on-site as a host to using MediaTemple, an online hosting provider, because they have dedicated staff monitoring the servers, configuring them, and keeping them secure and online so we would not have to devote time to those same tasks. We chose their GridService because with this, as our site grows, it would be able to scale it across server clusters seamlessly without any input from us. We also switched our mail servers over to Google's servers, so we would not have to worry about their configuration, and set up all outgoing messages to be signed cryptographically with a key at our domain so they would not be marked as spam.

We would recommend that any group who continues this project be made up of three or four people as follows: two computer science majors with experience with PHP, CSS, jQuery and JavaScript, and human-computer interaction, one entrepreneurship or business major with technical experience, and/or one management of information systems major, preferably with some experience in marketing. Our recommendation would be to pick up where we left off, to continue to refine and develop the requirements through continued surveys and interviews with potential users and stakeholders, to continue to develop the site's functionality and—importantly—its user interface, and to spend much more time developing and cultivating personal connections and promoting the site through them.

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Appendix A: Initial Interview Questions

1) Where did you find information that was helpful in guiding your academic and career choices? Where did you go for advice as you progressed academically: peers, supervisors, professional societies, websites?

2) How many other postdoctoral researchers do you know? How do you know each of them?

3) What social networking sites do you use? How do you use them?

4) How do you deal with job instability? How do you plan for your next research gig or position?

5) How have you gotten research jobs in the past? How did you get *here*?

6) How do you network professionally? How do you connect with other members of the scientific community?

7) How do you circulate your curriculum vitae? Do you have an online portfolio? If so, how do you use it? Do you use email or printed copies?

8) When was the last event (lecture, conference) you attended? What can you tell me about it?
   a) Did you network with anyone?
   b) What did you go *for*? The networking?

9) How often do you attend lectures or conferences?
   a) How do you normally find out about these lectures or conferences?
   b) What do you think might increase your attendance at lectures or conferences?

12) When was the last time you GAVE a lecture? What can you tell me about that experience?
   a) Did anyone network with you or approach you?
   b) How did you arrange to give that lecture?
   c) When do you plan to give your next lecture?

13) Would you like to increase or decrease the amount of lectures you (have to) give? Do you enjoy giving lectures?

14) Do you make use of any services provided for underrepresented or minority professionals?
   a) Why or why not?
   b) How do you use them?
   c) Have they been helpful?
   d) How do you *feel* about using them?

15) Where do you go now when you have questions about your professional future and career?

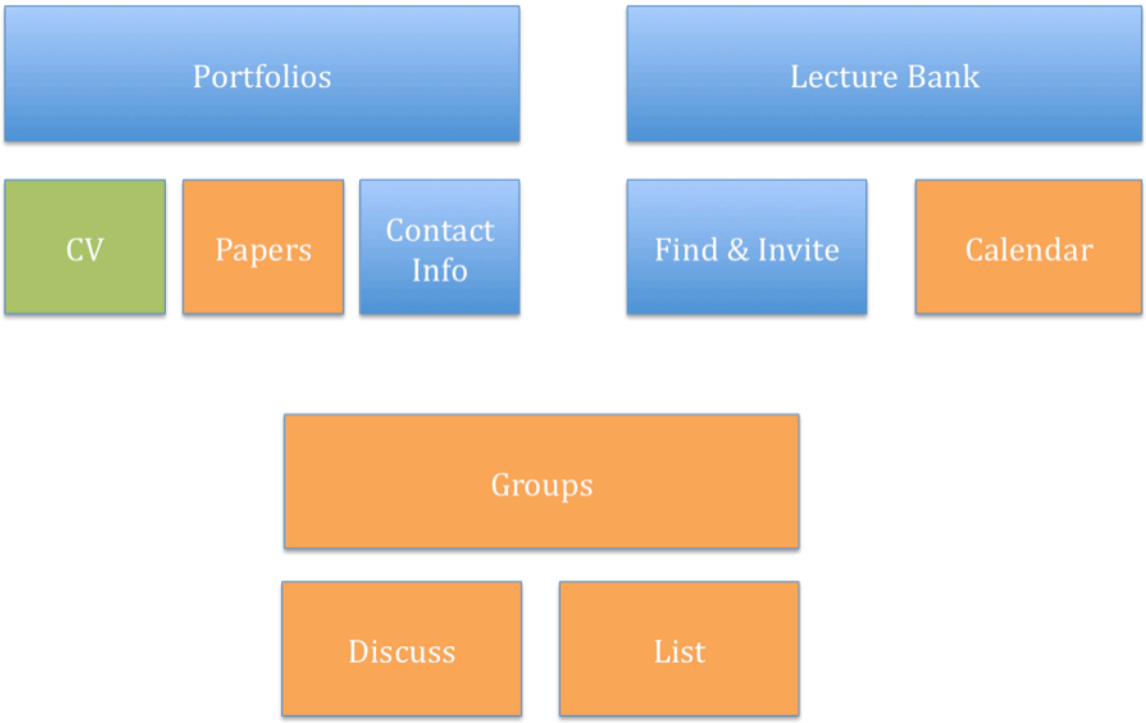
Appendix B: Site Survey

	Profile	Document Sharing	Contacts	Groups / Networks	Messaging	Journals / Publications	Access to Writers	Blog	Events	Job Finder
GrowSTEM	Y	Y	Y	Y	Y	N	N	Y	Y	N
My PRGenie	Y**	Y**	N	N	Y**	N	Y	N	N	N
LinkedIn	Y		Y	Y	Y			Y		
Facebook	Y	Y	Y	Y	Y	Links	N	Y	Y	N
Twitter	Y					Links	N	Y	Y	N
Biznik	Y		Y	Y	Y			Y	Y	
Ecademy	Y		Y	Y	Y			Y		
Plaxo	Y	N	Y		Y	N	N	N	Y	N
Ryze	Y		Y	Y	Y			Y	Y	
ASAS*	Y	N	N	N	N	Y	N	N	Y	Y
Science NetLinks	N	Y	N	N	N	Y	N	N	N	N

*American Society for the Advancement of Science

**Limited

Appendix C: Site Focus and Organizational Changes



All items were present in the initial design, but as we focused on specific features, the sections in orange were either removed entirely (Groups and Papers) or had their functionality reduced to the essentials (Calendar). The section in green, the CV, became more prominent as we rolled part of the old Papers functionality into it by incorporating abstracts.