Social Matching for Health Researchers

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Abstract: This paper is a report on the findings of a study on a novel collaborative web tool that aims to foster collaboration and increase social interaction within organizations. The study was conducted with the research communities in health and continuing care within the Faculty of Health Sciences at the University of Ottawa and the Élisabeth Bruyère Research Institute. The large number of researchers and physical disconnection of the workspaces limit social interaction amongst researchers, and lead to unawareness about opportunities for interdisciplinary collaboration. Qualitative analysis based on personal interviews and focus groups was done to determine whether the proactive construction of a social network using social matching techniques is an effective approach to both promote and analyze the social interaction across these two organizations.

Introduction

Large organizations often have physical and social barriers that prevent the communication between individuals with shared interests and objectives. In the case of universities and research institutions, this leads to missing collaboration opportunities that are necessary for attracting funding and studying challenging problems, recruiting students and identifying possible thesis/dissertation committee members and tracking productivity of research clusters. The Élisabeth Bruyère Research Institute is a leading centre of research, education and innovation for the wellbeing of aging Canadians and those requiring primary, continuing and palliative care. The Institute is a large organization and has partnerships with other large research organizations including the Faculty of Health Sciences at the University of Ottawa. The Faculty of Health Sciences and the Élisabeth Bruyère Research Institute include over 150 independent scientists. This community of researchers is physically spread over more than seven sites within the city of Ottawa, including Bruyère Continuing Care, the Élisabeth Bruyère Research Institute, and the five sites of the Faculty across the University campuses. As a result, the level of social interactions amongst researchers is highly limited.

Given the strong potential for interdisciplinary work within the Institute and the Faculty, the administrations are interested in considering novel ways to help researchers to find collaborators and experts to whom to ask questions. This initiative is crucial to fully exploiting the synergies between the Institute and its partners. In addition, the two organizations require a tool for assessing the strengths and weaknesses of their research communities in order to plan the growth of their programs and promote their achievements to the general public.

The Study

The objective of the study is to evaluate the potential of social matching technology to enhance social connections within an academic environment, and to help researchers discover colleagues with whom they can collaborate. In contrast to the standard social network model that connects people who already know each other, social matching aims to connect people who are compatible in some respect, and who may have never met. A "proactive" social network built by a social matching algorithm frees its users from having to explicitly establish connections or finding groups to join. As a result, it promotes social interaction and fosters collaboration within an organization. The general premise of social matching is that individuals require some assistance to find people with whom to partner or share knowledge and experiences. The individuals indirectly control their connections with others by updating their own profile information.

Social matching has a strong theoretical foundation and a host of algorithms and tools have been proposed. Terveen & McDonald (2005) advance a framework for studying the different aspects of the problem, and pose general questions to investigate. Raban et al. (2009) explore the privacy aspects of using user profile information to compute matches. Jones et al. (2004) propose a social matching approach that takes the geographical location of users into consideration. Moreover, social psychologists have investigated methods for motivating contributions and increasing community participation (Beenen et al. 2004; Ludford et al. 2004) as well as the effect of group size in collaborative activities (Williams & Karau 1991). A subproblem that has also received considerable attention is social question-and-answer. In this case, the goal is to match user questions against user profiles in order to deliver the questions to the users that are best qualified to answer them. Kautz et al. (1997) examine the problem of referring questions to experts who may have constraints for incoming questions. White et al. (2011) propose the IM-an-expert system and evaluate the effects that community size has on the rate to which experts are contacted and their response times.

In the social matching framework, the profile information used to match users is a key aspect of the problem that depends on the domain. For example, matching can be done based on keywords, but the semantical and hierarchical relationships of keywords are organization-dependent and must be considered in order to yield effective matches. Similarly, the information that is needed to evaluate the level of expertise of users on given topics depends on a multitude of factors that are related to the nature of the organization. This highlights the need and importance of the study conducted on the Faculty and the Institute. These organizations have specific requirements regarding how best to match individuals in order to achieve a measurable increase in their social interaction.

The study was conducted as follows. We collaborated with the administration and scientists of the Institute and of the Faculty in assessing the structure of the information that is required to match researchers between the two centres. This information allows us to tailor existing social matching algorithms to the needs of the organizations and evaluate them in the field with a selected set of researchers. We expect that the findings of the study will be used as a model for the general problem of matching researchers across other partner organizations of the Institute and the Faculty.

For this study, we employed a tool called UniWeb for creating online social matching websites provided by Proximify, a startup company founded by one of the authors of this paper. The underlying social matching engine computes overlapping clusters of individuals based on their profile information. In our case, each cluster represents a research theme in which all members of the cluster are interested. The objective of clustering is twofold. First, the clusters are used to generate simple visual maps that are presented to the individuals in order to help them understand their implicit connection with other members. Second, the clusters are used to enable users to post messages to be read by the members of a selected cluster. This is similar to the way a LISTSERV works, but with the added benefit that the relationships between the research themes are considered when delivering the messages. For example, Midwifery and Maternal Care are subareas of Pregnancy, and therefore, a researcher interested in Pregnancy will receive messages posted to either of these two subareas, while a researcher interested only in Midwifery will not receive messaged posted to the Maternal Care cluster.

The objective of the study is to evaluate a novel tool for the creation and presentation of implicit social networks based on clustering researchers according to their research interests. Success can be evaluated by considering how meaningful and useful the generated clusters are for the researchers at the Élisabeth Bruyère Research Institute and at the Faculty of Health Sciences. To this end, the Institute and the Faculty administrations recruited a group of volunteers formed by scientists and administrators from the Institute and the Faculty.

We performed a qualitative analysis of the impacts of the tool. Personal semi-structured interviews were conducted with the participating volunteers in order to evaluate: (1) the functionality of the tool, (2) their satisfaction based on their personal needs and interests, and (3) their understanding of how best to use the tool to obtain the maximum benefit. Next, a focus group was organized with all the participating volunteers to obtain feedback on how to improve the tool by setting upgrade priorities as a group. The participants signed an ethics consent form approved by the University that guaranteed their participation would be anonymous. Therefore, it is important to note that the faces, names and research interests used by the software were taken from the public webpages of all researchers in the Faculty of Health Sciences, and chosen randomly to illustrate the figures in this work.

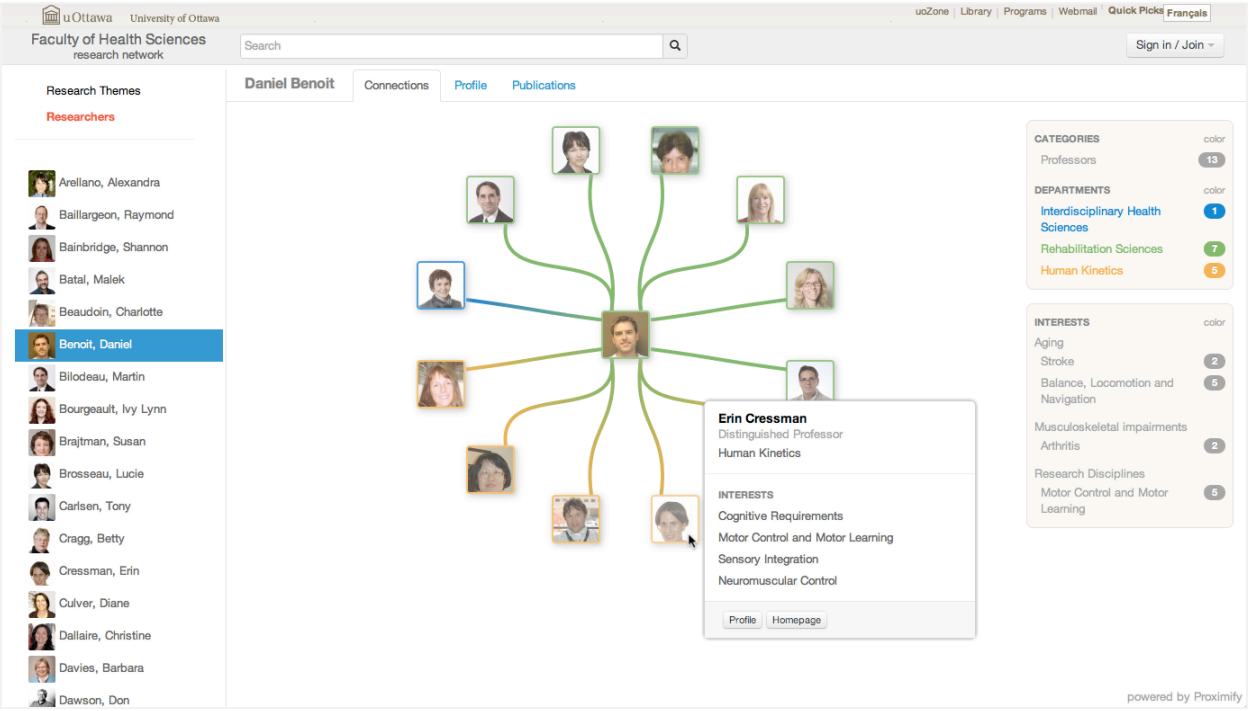

Figure 1: A visual map of the connection between researchers based on their common interests and color-coded by department affiliation. A popup window presents information about the interests of a member. When hovering the mouse over the connections (not shown), a tooltip displays the research themes that links two members. In addition, the right hand sidebar summarizes the nature of the connections and allows for filtering the map according to selected attributes.

Related Work on Social Matching

Social matching requires profiling users and discovering relevant connections. The literature in this area attempts to answer questions such as: What type of information should the system represent about its users, and how should it acquire this information? What is an appropriate model for good matches? How should the system compute matches? Kobsa (2001) provides a survey of algorithms for constructing *user models* (also known as stereotypes) in order to create meaningful user profiles. For instance, Rich (1979) proposes to create user models with the goal of adapting the system interaction to each user class, tailoring the functionality that the system provides and customizing the information that is presented. The approaches in this area differ on the algorithms used for clustering users, and on the creation of model hierarchies as a method for having both general and specialized stereotypes (e.g., the UMT model proposed by Brajnik and Tasso (1994)).

There is also relevant work on "Group recommenders" (e.g., O'Connor et al. 2001; McCarthy and Anagnost 1998). Such algorithms aim to model groups of users in order to recommend "things" to the group members. For example, a "group recommender" algorithm can be used to suggest new interests to users who might not have listed them in their profile but that, based on the people to whom they are connected, the system can infer that the user might actually share those interests. O'Connor et al. consider only self-defined groups while McCarthy and Anagnost created the groups automatically by considering key features that must be shared by all their members. Clustering and Bayesian Networks are two popular approaches used for creating groups (Breese et al. 1998).

We are interested in evaluating what information leads to the most relevant matches, and how best to deal with the different ways in which users might describe their interests, expertise and discipline. An interesting aspect of matching based on user profiles is to determine whether it is viable to incorporate information labeled as private by the users for the exclusive purpose of matching. In this model, a user can be asked to label each piece of information in his/her profile as: (a) public, (b) only available for matching purposes, and (c) unavailable for any

purposes. For example, some researchers might not want to make public their list of publications, but might accept the system using such list to determine expertise level and compute matches.

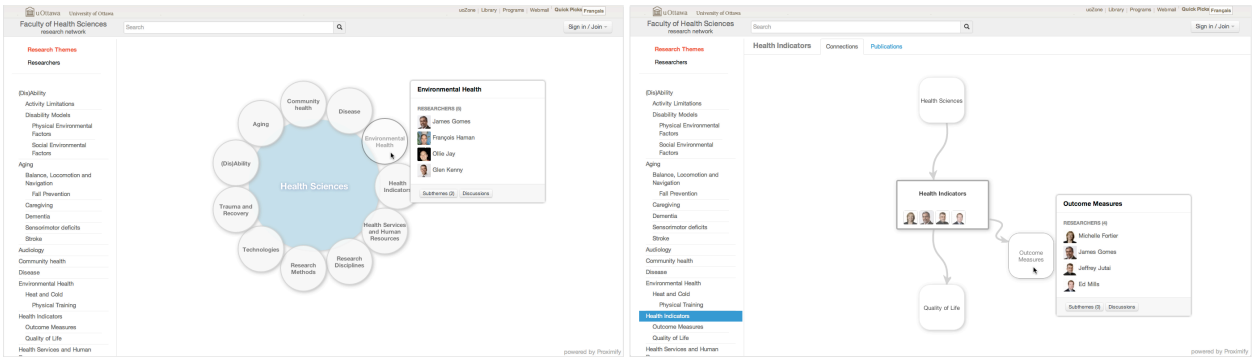

Figure 2: Hierarchy of research themes. Left: the top research themes of the Faculty of Health Sciences. Right: Clusters of researchers with a common interest on the same research theme. The connections between themes show the relationship between a parent theme (center) and its subthemes (periphery).

A related problem to the computation of matches is the assessment of matching relevance. This is necessary to determine which matches are presented to the user "by default," and which ones are displayed only when the user explicitly changes the matching parameters. For example, the geographical location of users (Jones et al. 2004) is a discriminative factor that can be incorporated by default when computing matchers, but can be turned off by the user if desired. Our objective is to evaluate what are the most appropriate default features to consider when matching researcher within the Institute, the Faculty and between the Institute and the Faculty. This aspect of the problem has been discussed by Liberman et al. (2001), where the phrase "zero-effort interfaces" was used to emphasize that social matching aims to free the user from having to make explicit decisions about their social connections.

Setup and Tool

We decided to create connections between researchers based on their common research interests (Fig. 1). The first challenge we faced was deciding how to encourage researchers to not choose research themes that were too specialized. The objective was to avoid having interests that were too specific, leading to few interconnections and little analytic value for the administration. We addressed this problem by letting the administrators of the Faculty create a hierarchy of research themes (Fig. 2). The administrators started from a list of themes built by asking scientists at the Faculty of Health Sciences to submit up to three themes that summarized their research areas. This was complemented with the information collected by a web crawler designed to automatically retrieve the information of professors displayed in their official university web pages (including their pictures). The list of themes and the keywords extracted by the web crawler were reviewed by the research facilitator, the Vice Dean Research and one of the Academic Unit Directors to extract an initial list of themes. The VD Research and Research facilitator then reviewed and forced the themes into a preliminary hierarchy that was used in the first iteration of the network. This iteration was the starting point for testing of the network by scientists.

Initially, over 200 distinct words were used to identify research themes of approximately 125 scientists. Additional themes were added through word extraction from the on-line profiles. The preliminary hierarchy consolidated like words (e.g., aging, elderly, older adults) and identified 11 top-level (Level 1) themes. Subsequent analysis resulted in 2 to 14 Level 2 sub themes for each top-level theme and 2 to 7 Level 3 subthemes for each Level 2 theme.

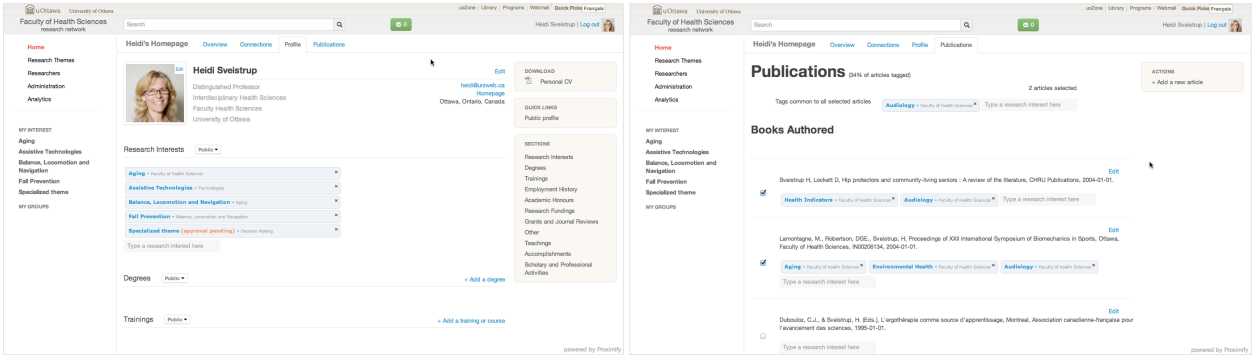

Figure 3: Editable profile. Left: the main profile page lets researchers add or remove research interest. New interests can be added, but remain in pending status (orange text) until they are approved by an administrator. Each section in the profile has a privacy selector that allows the users to exclude a section from public viewing. Right: The publications section has a dedicated page in which the researcher can tag each reference with one or more research themes. Multiple references can be checked and tagged as a group using the tagging tool at the top of the page. In this example, two publications are selected and their common research theme "Audiology" is shown in the batch-tagging tool.

The participants were able to either: (a) define their research interests by selecting themes from the hierarchy curated by the administrators, or (b) type the name of a theme not in the list. During the study, we allowed the researchers to either select interests from levels two and three of the hierarchy, or create new interests as long as they identified a level two or higher theme as the parent of their proposed theme. Any new research theme proposed by a member was given a "proposal" status, and added to a list of themes to be approved by an authorized member of the administration (Fig. 3). The administrator was given the following options for each proposal: accept/modify, rejected, or accepted as a synonym of an existing theme.

One of the primary objectives of the software is to allow Universities to showcase their research to prospective students in order to attract the top students to their programs. The most common method to show the strength of a Faculty or department on the web is to display the list of publications of each faculty member. However, lists of publications offer little information about the research themes associated with each article, and can be difficult for a prospective student to get an overview of the work inside a whole Faculty. The software tool that we evaluated offers a potential solution for this problem by allowing researchers to tag their publications with research themes (Fig. 3 right). This requires some effort from the users, but the rewards are immediate. Each tagged article becomes listed not only in the user's profile, but also under the webpages associated with each research theme (and their parent themes), and each user's group, such as labs or research projects. For the latter, it is considered that an article belongs to a group (or project) if: (a) it has at least one research theme in common with the interests of the group, and (b) its publication date is within the time span in which the author of the article belonged to the group.

The tool also has the capability of letting professors and students add pieces of work to their profile, and specify the student/supervisor relation that they have with the work. For example, a professor can add herself as the supervisor of a Master's thesis, define the range of time associated with the thesis, and select the author of the thesis. This makes the system inform the selected author that he/she was selected as author, and request the necessary approval in order to validate the relationship. Similarly, it is also possible for the author to create the relationship in the system by entering the thesis information and selecting one or more supervisors for it. The supervisor/student relationships are then combined with the research interests and publications of each individual to present Faculty administrators with valuable analytics about their supervision programs in each area.

The software tool collected statistics on the distribution of research interests, publications per research themes, size and activity of research groups and other data. This data was presented only to users in the group of Faculty administrators. In addition, the tool retrieved statistic data from the public database of the Canadian Institutes of Health Sciences (CIHR) in order to provide context to the Faculty data (Fig. 4). The objective of the analytics is to present administrators with up-to-date information that they can use to manage the allocation of resources in the Faculty and the Institute, and ultimately, allow them to work towards increasing the chances of obtaining more research funding each year.

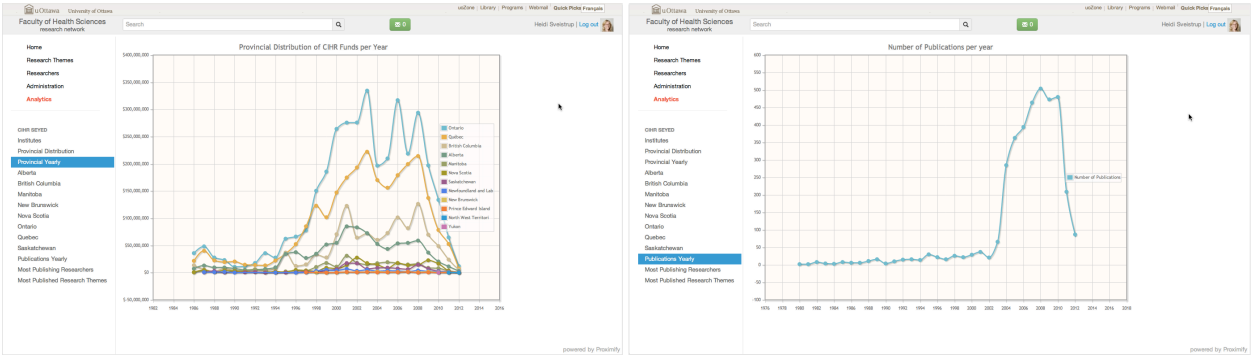

Figure 4: Analytics for the Faculty administrators. Left: Funding statistics from the Canadian Institutes of Health Sciences is downloaded weekly and made available to administrators. This chart displays a fictitious provincial distribution of funding per year. Right: Faculty statistics are used to populate charts based on the needs of the administration. The chart shows a fictitious number of publications in the Faculty over the last 7 years. It is important to note that the data depicted in these example plots should not be considered accurate, since the data is incomplete, especially for the most recent years.

Participants and Methodology

The UniWeb website was made accessible to a group of researchers from the Faculty of Health Sciences at the University of Ottawa and from the Élisabeth Bruyère Research Institute. Two individuals with primarily research support roles at the Faculty of Health Sciences were also included. Participants were introduced to the system during a face-to-face workshop that lasted approximately 45 minutes. One participant joined by teleconference and followed all instructions for navigating the network on his remote computer while the on-site group followed the study investigators directly. The group of participants was formed by 3 scientists from Rehabilitation Sciences, 1 scientist from the Interdisciplinary School of Health Sciences, and 1 staff member from the Research Office of the Faculty. A sub-group of scientists had dual roles with the Élisabeth Bruyere Research Institute. All scientists had academic leadership positions in either the Faculty of Health Sciences or the Élisabeth Bruyere Research Institute that sensitized them to the importance of collaboration, student and training challenges, and the benefits of interdisciplinarity.

We organized a focus group with the participating individuals after they completed a two-week period of evaluation of the website. During the evaluation period we received emails with questions. The first few questions from two participants were related to web browser incompatibilities, which we were able to resolve. The participants visited their websites using PCs, Macs and iPads and a range of different web browsers. Subsequent emails were focused around usability issues and feedback. A one-hour focus group was held at the Élisabeth Bruyère Hospital with all the participants in the study.

Findings

Four main issues emerged in the interviews, workshop and focus group: the perceived benefits of the tool as a way of discovering potential collaborators, the choice of research themes hierarchy, the potential impact for current and prospective graduate students, and the relevance of the tool for researchers in administrative roles. We present the findings on each of these four topics in the subsections below. Additional comments during the meetings were focused on user interface questions, request of new functionality, privacy concerns and general system usability feedback.

The comments during the introductory workshop suggested that the participants were able to understand the potential of the tool as a way of discovering potential collaborators and displaying their publications online within different contexts. After the participants had time to use the system, we were able to confirm the hypothesis that the tool was a good solution for improving their awareness about the research interests of their colleagues. In addition, we discovered that the choice of research interests is more deeply related with a sense of scientific identity

than we expected. The conclusion is that a novel approach is needed in order to meet the expectations of the researchers, and to build a theme hierarchy with which they can identify.

Regarding system usability, the most important issue was raised in an email during the trial period: "*I couldn't change my themes – this made me sad*". The problem was caused by the fact that the user could take two paths to arrive to her profile: go through the Home menu and then click the profile page, or find herself in the list of researchers, and then see her profile. In the former case, the profile was in editable mode, but in the latter, the profile was in display-only mode. This aspect was discussed by the focus group and it became clear that everyone expected that the profile of the logged on user to be always editable regardless of how one arrives to it.

(a) Awareness of Colleagues' Interests

We used one of the Rehabilitation Science professor's profiles to show how the mapping by theme and by individual would work. As soon as this professor's profile was displayed (as the network of connections to researchers in other academic units within the Faculty), she commented "I am looking for who are my people in human kinetics… It's very cool". To put this in context, it is important to note that while the graph showed that she had connections in 4 out of the 5 departments, she was only aware of her connections within 3 of them. She had little knowledge of how the community in the School of Human Kinetics, located at a different university campus approximately 5 km from the School of Rehabilitation Sciences, had evolved over time and what her connections were with scientists in Human Kinetics.

Despite including primarily participants with significant years within the Faculty and who have had or are currently in upper level administrative positions, there were a number of comments indicating that the knowledge of research within the Faculty (who is doing what) was limited:

"For me it wasn't so much that. It was I didn't know this person did this, so if I have an aspect of this in my next thing, I want to talk to that person."

"I loved having all the info regarding all the profs so handy – I could get an idea of the entire faculty in about 20 minutes – fantastic."

"I discovered several people in the Faculty that I didn't know where there just by seeing their faces in the list of researchers. (…) I would have never played with the Faculty website and done that."

"I wasn't aware so many other people…[do research]…in some areas, and then, depending on the project, I would want to find out more. So it really does enhance your awareness about what is going on."

The UniWeb used information from a Faculty database and website that was incomplete (i.e., not all professors were on the website and the data for professors who were in the database was not complete). Therefore, we expect that the value of the network will be greater once a full database is developed.

(b) The Hierarchy of Research Themes

A researcher from Rehabilitation Sciences commented on the terminology used for themes and its relation to "The International Classification of Functioning, Disability and Health", also known as the ICF. "The ICF is a classification of health and health-related domains. These domains are classified from body, individual and societal perspectives by means of two lists: a list of body functions and structure, and a list of domains of activity and participation. Since an individual's functioning and disability occurs in a context, the ICF also includes a list of environmental factors" (ICF 2012).

While the terminology used for research themes was created by the Faculty administrators, it was pointed out that some terms used were from the ICF while others were no longer used in the ICF. Initial discussion was that the Faculty should move towards using this World Health Organization framework and ensure that all terminology is consistent with it. The comment and the corresponding decision reflect an immediate change in behavior that could have long-term impact at the Faculty. Specifically, the network will provide a means for standardizing some of the terminology used when discussing aspects of research by individuals with very broad disciplinary training.

"I was a little concerned about having to fight for my new topic. I didn't want to have to do that."

"Give everybody a chance to have their themes up there"

"I want to be known by a certain area, whatever that is."

"Let the investigators define with one hundred words what they do in each theme"

One of the primary objectives for constructing the social networking site was to provide a mechanism for all scientists to find individuals across the Faculty and Institute with similar research interests. The initial themes used for creating a starting place were identified from a static list and forced into a hierarchy. At the initial participant meeting, the specific terminology used was questioned and the suggestion was made to use the World Health Organization taxonomy. Once the study participants had worked with the system, this approach was re-discussed and the users felt that a single taxonomy may be limiting. The recommendation that will be tested for next stage implementation is to request that each academic unit select a relevant taxonomy for their area of study (e.g., ICF for Rehabilitation Sciences; Nursing Interventions Classification for Nursing Sciences).

Discussion of implementation led to a potential solution that drew uniform consensus. Step 1: give researchers the choice of selecting exactly two research themes "that define them as researchers" and that are not subject to the approval of the administration preferably from within one of the taxonomies identified above. This could result in a maximum number of 250 research themes. The themes would be grouped where relevant (e.g., aging, older adults, elderly could be grouped into aging). Step 2: Researchers would be invited to identify any of the final list of themes within the hierarchy of existing themes. Thus a researcher could be identified with two research themes in the initial proposal round (e.g., Environmental Factors, Assistive Devices) as well as additional themes that would have been submitted by other researchers (e.g., Aging, Stroke). Step 3: On an ongoing basis, researchers would be able to identify and submit new themes and have them approved by the Faculty administrators. The third step permits the continuous updating of the research themes that would also be needed when hiring new researchers or if a cluster of research becomes less relevant due to loss of researchers. The intent is to strike a balance between respecting how scientists describe themselves in terms of research themes and avoiding a long list of different themes as it occurred with pasts attempts to survey the researchers' interests within the Faculty.

The consensus among all participants was that it was probably better to start from a broader selecting of user themes and then try to build the hierarchy from that.

The work associated with loading data onto the system was identified as a significant issue:

"It's going to be a stretch to get people to label the themes associated with their publications."

Multiple approaches to minimizing the burden were suggested: 1) use databases already in existence or under development at the University to minimize duplication of work; 2) use the UniWeb to input data into other databases (e.g., CommonCV).

One of the significant funding agencies for the researchers at the Faculty is the Canadian Institutes of Health Research. One participant suggested applying a CIHR lens to the network since when putting together a grant proposal, one may need to look for collaborations in the areas defined by the CIHR classification. Group discussion however suggested that the CIHR lens would be limited, is less developed in two of the four pillars of research and would be less relevant for a large subset of investigators. One alternative was to add a sublist of categories:

"When looking for collaborations in a CIHR project it might be a better option for me to look for CHIR codes or in general define the categories as needed"

(c) Relevance for Administrators

We asked the participants if they considered the tool useful for themselves in their administrative roles. As administrators, a significant challenge is to capture and maintain updated research metrics.

"Yes. For annual reports, it'd be fantastic. Ideally [for annual reports] the information would be number of publications, grants, and number of students".

"If the database is up-to-date, and it integrates with the online cv [CommonCV and/or Academic CV], it'd be fantastic".

"Yes. Trend lines… on publications, grant amounts, students. For example, [we want to answer whether] the coming online of our PhD program, will it increase productivity in terms of all these [metrics]."

In certain instances, privacy concerns must be considered when including and sharing information. This would necessitate a mechanism where professors "*could approve the information that he wants to share with the institute [or have visible on the web]*".

(d) Relevance for Current and Prospective Students

The UniWeb may be an additional mechanism to support engagement at the university and building an inclusive and vibrant community.

"If we could keep track in a student group of their scholarships, papers and presentations that would help us as promote ourselves as a very active school, and would help the students to start to have more of a web presence towards their careers. That would be great. Another thing that this is useful for is for when students are looking for committee members because it often takes so long."

"You can look at it from a number of perspectives. For a prospective student who is looking to see who they might want to have as a thesis supervisor or have on their committee, so certainly zeroing in on the content is important. But another thing for the student is to see how much experience this person [potential supervisor] has in my category, PhD, postdoc…. Right know they have to get the professor CV if it is there and try to find that information… having just the counts of how many master's, how many PhD could be very useful."

During the focus group, the issue of enabling the communication of prospective students with current students was brought up.

"Yes, I think that could be quite helpful, also for the web presence of the [current] students because you not only can see who they are but you can actually talk to them."

The participants also suggested that the information provided by the tool regarding the work done at the Faculty and the relationships between scientists was a good way of addressing their objective of improving the academic experience for students.

Conclusions

The Bruyère Research Institute and the Faculty of Health Sciences at the University of Ottawa are interested in addressing an organizational challenge associated with their sizes and geographical locations, which create a research community that is spread over seven sites located in distant parts of the same city. The large number of researchers and physical disconnection of the buildings and campuses limit social interaction amongst researchers and lead to a lack of awareness about opportunities for interdisciplinary collaboration. The main hypothesis of our study is that social matching can be an effective tool to address these challenges because it is based on the concept of connecting people who are compatible in some respect, but who may have never met. We expect that the findings of the study will be used as a model for the general problem of matching researchers across other partner organizations of the Institute and the Faculty.

In future work, we will evaluate the impact that the UniWeb has on the number of research grants that are obtained by the body of researchers of a Faculty. This includes considering the benefits of attracting more academically accomplished graduate students to the program as a result of the improvements in showing the production of groups and researchers within a Faculty. We expect that helping researchers and students find potential collaborators for publishing and grant proposal applications should lead to a measurable increase in the number of successful grant applications over the years.

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References

Terveen, L. and McDonald, D.W. (2005). *Social Matching : A Framework and Research Agenda*. ACM Transactions on Computer-Human Interaction.

Raban, D., Ricken, S., Sukeshini, A., Laws, N., and Jones, Q. (2009). *Hello Stranger! A Study of Introductory Communication Structure and Social Match Success*. System Sciences. 2009.

Jones, Q., Grandhi, S., Terveen, L., and Whittaker, S. (2004). *People-To-People-to-Geographical-Places: The P3 Framework for Location-Based Community Systems*. Computer Supported Cooperative Work.

Kautz, H., Selman, B., and Shah, M. (1997). *ReferralWeb: Combining social networks and collaborative filtering*. Communications of the ACM.

White, R., Richardson, M., and Liu, Y. (2011). *Effects of Community Size and Contact Rate in Synchronous Social Q & A*. In proceeding of the ACM Computer Human Interaction.

Beenen, G., Ling, K., Chang K., Wang, X., Resnick, P., and Kraut, R. (2004). *Using Social Psychology to Motivate Contributions to Online Communities*. Proc. CSCW.

Ludford, P.J., Cosley, D., Frankowski, D., and Terveen, L. (2004). *Think different: increasing online community participation using uniqueness and group dissimilarity*. Proc. CHI.

Williams, K.D. and Karau, S.J. (1991). *Social loafing and social compensation: the effects of expectation of co-worker performance*. Journal of Personality and Social Psychology.

Rich, E. (1979). *User Modeling via stereotypes*. *Cognitive Science 3*.

Kobsa, A. (2001). *Generic User modeling systems*. In User Modeling and User-Adapted Interaction.

O'connor, M., Cosley, D., Konstan, J. A., And Riedl, J. (2001). *PolyLens: A recommender system for groups of users*. In Proceedings of the European Conference on Computer Supported Cooperative.

Mccarthy, J. F. And Anagnost, T. D. (1998). *MusicFX: An arbiter of group preferences for computer supported collaborative workouts*. In Proceedings of the ACM Conference on Computer Supported Cooperative Work.

Breese, J. S., Heckerman, D., And Kadie, C. (1998). *Empirical analysis of predictive algorithms for collaborative filtering*. In Proceedings of the 14th Conference on Uncertainty in Artificial Intelligence.

Lieberman, H., Fry, C., And Weitzman, L. (2001). *Exploring the Web with reconnaissance agents*.

Brajnik, G. and Tasso, C. (1994). *A Shell for Developing Non-monotonic User Modeling Systems*. International Journal of Human-Computer Studies.

ICF. (2012). http://www.who.int/classifications/icf/en/.