



September 7-10, 2014
St. John's / Port Rexton
Newfoundland, Canada

Eighth Annual Strategic Leaders Global Summit

*Interdisciplinary Learning in
Graduate Education and Research*

CGS acknowledges ProQuest's generous support of the 2014 Strategic Leaders Global Summit



Location Information

The Summit will be held at the **Sheraton Hotel Newfoundland in St. John's**, and at **Fishers' Loft in Port Rexton**.

Hotel details:

Sheraton Hotel Newfoundland
115 Cavendish Square
St. Johns, NL
A1C 3K2 Canada
Phone: +1 (709) 726-4980
www.starwoodhotels.com

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Port Rexton, NL
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2014 Strategic Leaders Global Summit on Graduate Education: Timed Agenda

Sunday, September 7, 2014

Time	Details
15:00–16:00	Registration at Sheraton Hotel Newfoundland, Avalon/Battery Room
16:00–16:25	Welcome and Introduction, Avalon/Battery Room
	Noreen Golfman , Dean of Graduate Studies, Provost and Vice President (Academic) pro tempore, Memorial University of Newfoundland, and Suzanne T. Ortega , President, Council of Graduate Schools
16:30–18:30	Panel 1: National and Regional Contexts: Concepts and Structures of Interdisciplinarity
	Moderator: Noreen Golfman
16:30–16:40	Vahan Agopyan , Vice-Reitor/Vice-President, Universidade de São Paulo
16:40–16:50	Shiyi Chen , Dean of the College of Engineering, Peking University
16:50–17:00	Noreen Golfman , Dean of Graduate Studies, Provost and Vice President (Academic) pro tempore, Memorial University of Newfoundland
17:00–17:10	Liviu Matei , Provost, Central European University
17:10–17:20	Laura Poole-Warren , Pro Vice-Chancellor (Research Training) and Dean of Graduate Research, University of New South Wales
17:20–17:30	Nirmala Rao , Dean, Graduate School, The University of Hong Kong
17:30–17:40	James Wimbush , Dean, University Graduate School, Indiana University
17:40–18:30	Discussion
18:30–19:00	Break
19:00–19:30	Opening Reception, The Narrows, Main Floor, Sheraton
19:30–21:00	Opening Dinner, Court Garden, Sheraton

Monday, September 8, 2014

Time	Details
6:30	Breakfast service begins at Oppidan Restaurant, Sheraton, off main lobby
7:45	Assemble with luggage in main lobby to meet bus to Fishers' Loft
8:00	Shuttle departs for Fishers' Loft, Port Rexton
10:30	Arrival at Fishers' Loft
10:30–11:30	Inn check-in
12:00–13:00	Lunch in Fishers' Loft Dining Room
13:30–15:00	Panel 2: Creating an Institutional Culture that Values Interdisciplinary Learning
	Moderator: Liviu Matei , Provost, Central European University
	2a. Benefits of Supporting Interdisciplinary Learning and Research
13:30–13:40	Jay Doering , Vice-Provost (Graduate Education) and Dean, Faculty of Graduate Studies, University of Manitoba
13:40–13:50	Lesley Wilson , Secretary General, European University Association
	2b. The Role of Institutional Leadership
13:50–14:00	Denise Cuthbert , Dean, School of Graduate Research, RMIT University
14:00–14:10	Shireen Motala , Director, Postgraduate Studies: Research and Innovation, University of Johannesburg
	2c. Overcoming Common Barriers
14:10–14:20	Lisa Young , Vice Provost and Dean, Graduate Studies, University of Calgary
14:20–15:00	Discussion
15:00–15:30	Break
15:30–17:00	Panel 3: Building Interdisciplinary Degree Programs
	Moderator: James Wimbush , Dean, University Graduate School, Indiana University
	3a. Administrative and Organizational Issues
15:30–15:40	Lucy Johnston , Dean of Postgraduate Research, University of Canterbury
15:40–15:50	Robert Augustine , Dean of the Graduate School, Eastern Illinois University

	3b. Engaging Faculty
15:50–16:00	Tao Tao , Executive Dean, Graduate School, Xiamen University
16:00–16:10	Stefanie Thorne , Head of Research and Enterprise Services, University Campus Suffolk
	3c. Program Assessment
16:10–16:20	Melita Kovacevic , CDE Steering Committee Chair, European University Association
16:20–17:00	Discussion
17:00–17:20	Coffee Break, Conference Centre
17:20–18:30	Panel 4: Innovations in Interdisciplinary Learning Moderator: Laura Poole-Warren , Pro Vice-Chancellor (Research Training) and Dean of Graduate Research, University of New South Wales
	4a. Informal or Extracurricular Opportunities
17:20–17:30	Nancy H. Marcus , Dean of the Graduate School, Florida State University
17:30–17:40	Marie Audette , Dean, Faculty of Graduate and Postdoctoral Studies, Université Laval
17:40–17:50	Roger Horn , Dean of Research Training, Deakin University
	4b. Mentoring and Advising the Interdisciplinary Student
17:50–18:00	Mark J.T. Smith , Dean, Graduate School, Purdue University
	4c. Electronic Resources for Learning and Research
18:00–18:10	Rafael Sidi , Senior Vice President and General Manager, ProQuest Information Solutions
18:10–18:30	Discussion
18:30–19:00	Break
19:00–20:30	Dinner in Fishers' Loft Dining Room

Tuesday, September 9, 2014

Time	Details
7:30	Breakfast in Fishers' Loft Dining Room
8:45	Bus departs for Trinity
9:00–11:30	Organized Visit to Trinity (partners welcome)
12:00–13:00	Lunch in Fishers' Loft Dining Room
13:30–15:00	Panel 5: Structures for Interdisciplinary Research and Collaboration
	Moderators: Vahan Agopyan , Vice-Reitor/Vice-President, Universidade de São Paulo; Shiyi Chen , Dean of the College of Engineering, Peking University
	5a. Perspectives from Science, Technology, Engineering, and Mathematics (STEM)
13:30–13:40	Sue Berners-Price , Dean, Graduate Research School, Griffith University
13:40–13:50	Mohan Kankanhalli , Vice Provost, Graduate Education, National University of Singapore
13:50–14:00	Hans-Joachim Bungartz , Graduate Dean, Technische Universität München
	5b. Perspectives from the Humanities and Social Sciences
14:00–14:10	Verena Blechinger-Talcott , Director of the Graduate School of East Asian Studies, Freie Universität Berlin
14:10–14:20	Zaidatun Tasir , Dean, School of Graduate Studies, Universiti Teknologi Malaysia
	5c. Collaboration Across All Disciplines
14:20–14:30	Barbara Knuth , Vice Provost and Dean of the Graduate School, Cornell University
14:30–15:00	Discussion
15:00–16:00	Panel 6: Building and Sustaining External Partnerships
	Moderator: Nirmala Rao , Dean, Graduate School, The University of Hong Kong
	6a. Securing Funding for Interdisciplinary Education and Research
15:00–15:10	Maureen Terese McCarthy , Assistant Director of Advancement and Best Practices, Council of Graduate Schools

	6b. Interdisciplinary Collaborations with International Partners
15:10–15:20	Jiaping Wang , Executive Dean of the Graduate School, Zhejiang University
15:20–16:00	Discussion
16:00–16:30	Coffee Break, Conference Centre
16:30–17:30	Final Session and Drafting of Consensus Points
	Moderators: Noreen Golfman , Dean of Graduate Studies, Provost and Vice President (Academic) pro tempore, Memorial University of Newfoundland; Suzanne T. Ortega , President, Council of Graduate Schools
17:30	Group Photo
18:00–19:00	Break
19:00–20:30	Dinner, Fishers' Loft Dining Room

Wednesday, September 10, 2014

Time	Details
6:00	Breakfast in Fishers' Loft Dining Room
6:45	Assemble with luggage in lobby to meet bus to St. John's
7:00	Bus departs for St. John's
9:30	Arrival at Sheraton Hotel Newfoundland <i>(Taxis to airport available for those traveling that day)</i>
11:00–12:00	Press Conference, Sheraton Hotel, The Narrows

Introduction

Welcome and Introduction

Suzanne T. Ortega
President
Council of Graduate Schools

I am pleased to welcome you to the Eighth Annual Strategic Leaders Global Summit on Graduate Education. It is an honor to host my first summit as CGS President in collaboration with Memorial University of Newfoundland (MUN). Before I begin, I would like to thank Noreen Golfman for her leadership in developing the idea for the summit with CGS, and to her staff, particularly Ms. Annette Williams, who coordinated details on the MUN side. I also want to express my deep thanks to ProQuest for their continued sponsorship of the Global Summit since its inception. ProQuest is represented today by Senior Vice President and General Manager, Rafael Sidi. We sincerely thank you for making it possible to make the summit a tradition in the global higher education community.

History of the Global Summit

Today the Council of Graduate Schools continues its eight-year history of the Global Summit. It is perhaps fitting that I rejoin you this year, back in Canada where the summit began in 2007. I was present at that first meeting in Banff when we established principles for future collaborations, and identified the need for future summits on specific issues in graduate education internationally. It was an exciting prospect then, and I am gratified to see the promise of that first meeting fulfilled through this annual gathering. These summits have been hosted all over the world, bringing global context to the most pressing issues in graduate education.

The 2008 summit in Florence, Italy explored research ethics and scholarly integrity. In 2009 (San Francisco, California), the summit focused on ways to build and sustain graduate international collaborations. 2010 brought the summit to Brisbane, Australia, with a discussion of assessing quality in (post)graduate education and research training. The summit met in Hong Kong in 2011 to tackle the issue of tracking and building career pathways for graduate students. The 2012 summit in Bavaria, Germany focused on promoting global career pathways, considered in the context of “brain circulation.” Finally, last year’s summit, hosted in Budapest, Hungary, considered graduate education and the promise of technology.

Interdisciplinarity: A Pressing Issue for Graduate Education

This year’s convening assembles an outstanding group of graduate education leaders who will represent a range of national graduate education systems. Presentations will be made by speakers from 14 countries. This diversity allows us to access to a broad range of national and regional perspectives, allowing us to situate the idea of interdisciplinarity in a global context. Our theme this year, “Interdisciplinary Learning in Graduate Education and Research,” has emerged in past summits as a pressing and complex issue. As interdisciplinary research projects generate increased interest (and resources), our universities have been charged with preparing a next generation of research professionals that is both more global and more deeply collaborative than has often been true in the past. To challenge the frontiers of knowledge, our young scholars and scientists must be able to couple deep disciplinary understanding with the ability to engage in

work that crosses national and traditional disciplinary boundaries.

We presented you with a definition that views interdisciplinarity as “a means of solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches” (Klein, 1990, p. 196). A means of solving problems and answering questions: this definition leaves open the possibilities of interdisciplinarity as an inquiry stance, a toolkit, an attitude. There exist many different terms related to this concept—multi-, trans-, or cross-disciplinarity, to name a few. For our purposes at this summit, we chose the term that points towards a concept that is more than simply collaboration among those with differing disciplinary backgrounds. Mining the spaces between disciplines for innovative approaches—this is the promise of interdisciplinarity.

Understanding this value to scholarship and to the global community, we must support and cultivate interdisciplinary learning in our graduate students. But how can we best accomplish this goal, considering the attendant challenges? What, specifically, do we mean when we set “interdisciplinary learning” as a goal and how do we educate for it? Is there unique content associated with interdisciplinary learning? Is the approach to solving research problems different? Is the way that research questions emerge or the nature of the questions, themselves, different in discipline-based versus interdisciplinary contexts? How will we assess the learning in and the “value-add” of interdisciplinary graduate education? What role do external partnerships, physical spaces, and faculty incentives have in promoting interdisciplinary learning? At what point does an interdisciplinary degree program emerge as a logical next step to courses and certificates? What is the global value of an interdisciplinary degree? I do not have all of the answers, but I look forward to exploring these questions with you both during our scheduled panels and in more informal spaces.

2014 Agenda

We begin this afternoon as we have begun all global summits, with an overview of this year’s topic in graduate education and research as it is understood in various nations and regions. We have invited members of our steering committee to make formal presentations in this panel, but representatives from other countries are invited to share information and insights in the discussion following this panel. This first session will frame our discussion throughout the remainder of our time together. Formal panels are scheduled as follows:

- Tomorrow, our second panel will examine the processes by which we can create institutional cultures that value interdisciplinary learning and research.
- During panel three we will shift our focus to the building of interdisciplinary degree programs, and
- Panel four will address innovations in interdisciplinary learning, including non-degree program options and activities.
- On Tuesday, panel five will consider structures for interdisciplinary research and collaboration within STEM and the humanities as well as across broad fields; and
- Panel six will address ways that graduate institutions can potentially leverage a commitment to interdisciplinarity when engaging with external organizations and entities.

In our final wrap-up session on Tuesday, we will collectively think about possible points

of consensus that may guide our thinking on the role of graduate institutions in supporting interdisciplinary structures to enhance graduate programs and research. Our task will be to identify principles that will help our colleagues build upon our work here in their own local contexts. After reviewing all of the papers you generously submitted for discussion, I anticipate we will find consensus points in the following areas relating to interdisciplinarity:

- Communicating the value of interdisciplinarity to graduate education
- Constructing learning outcomes
- Gaining faculty support
- Providing opportunities for interdisciplinary learning and practice

On these and other points we hope to provide specific guidance for other worldwide graduate leaders dealing with this pressing issue.

Conclusion

In closing I would like to thank the Steering Committee for helping to shape and refine the agenda for this year's meeting, as well as each of you, whose preparation for this meeting will ensure that this evening's events and our full day of events tomorrow will no doubt make this year's summit a success.

1: National and Regional Contexts: Concepts and Structures of Interdisciplinarity

Interdisciplinarity and Graduate Studies in Brazil: Concepts and Structures of Interdisciplinarity

Vahan Agopyan
Vice-Reitor/Vice-President
Universidade de São Paulo (Brazil)

The need for an interdisciplinary approach to the development of academic activities is well understood and accepted by Brazilian universities, policy makers, and rulers. Even from the government point of view, this challenge is strongly supported. For instance, since 1999, in the Ministry of Education, the agency that supports and evaluates the graduate programs into the country (CAPES), has established an area dealing with interdisciplinary and multidisciplinary programs. Although all of the graduate programs are expected to have an interdisciplinary approach, some of them are in such way that it is not possible to point out a predominant subject to be classified in a specific area in this agency.

Thanks to this CAPES policy the number of interdisciplinary and multidisciplinary programs has increased sharply. In the year 2000 there were 54 programs classified in this area which consisted of 3.9% of the total graduate programs in Brazil (41 programs for master's degrees, 4 for doctoral degrees and 9 for both master's and doctoral degrees). The last available data are from 2012, when there were 440 programs (172 master's, 15 doctoral, 124 professional master's and 129 master's + doctoral) which represent 13.2% of the total programs in the country.

The same interest and effort has been pursued by other official agents, such as the Ministry of Science and Technology, directly and throughout its institutions, and also for state governments and state research supporting agencies like FAPESP, the research supporting agency of the State of São Paulo, the greatest agency in the country. Moreover, the Brazilian council of provosts for research and graduate studies of all the universities has defined interdisciplinarity as institutional commitment for research and education.

Despite all these efforts of Brazilian research policy makers, they are not translated into practice due to universities' conventional organization, and also due to the behavior of the internal commissions for selection or evaluation of the universities and research supporting agencies where their members do not always follow the policy established by the central administration. These members are faculties who are usually trained and acted in specific subjects, therefore they have difficulties to analyze and evaluate proposals with blended subjects.

The main research work in Brazil is carried out by public universities (federal or state ones) so their performance is of the utmost importance for the adoption of interdisciplinary activities. Unfortunately the public universities in Brazil have a lot of constraints that are the main drawbacks in Brazil for the increased expansion of interdisciplinary activities. The country regulation for academic activities and running the universities is extremely detailed and complicated so it is far easier to select the faculty members and students through disciplinary exams. This type of selection does not help that the interdisciplinary approach will be

always well accepted by the new participants. Furthermore, it is necessary to point out the strict academic structures in the public universities that are based in disciplinary department organizations and activities. The chair of an interdisciplinary research group or graduate program has to please different heads of departments in order to continue his activities, which demands time and effort. The management model of the public universities is also not helpful for interdisciplinarity. The universities are usually administrated in a very centralized way and the decisions are made during board meetings. It is not easy to satisfy a large number of participants in a commission, even if the head of this group is happy with the subject. Finally, there are external actions that can be considered as drawbacks in Brazil: it is difficult to publish an interdisciplinary paper in a large number of important journals or to convince the research supporting agencies to have the interdisciplinary project properly evaluated. Once again in these external institutions the activities are organized in commissions where the majority of members have a strong disciplinary attitude.

Taking into account the difficult scenario described in the previous paragraph, the tasks of the academic managers to increase the interdisciplinary activities are not easy. Nonetheless the output of interdisciplinary research groups and graduate programs are very encouraging. If these good results are adequately disseminated among the members, certainly our colleagues will be persuaded to accept this approach in order to improve their doings. It is our task to take persistent actions to convince our colleagues of the need for interdisciplinarity in academic activities.

At the University of S. Paulo (USP) this topic is intensively discussed in internal events, usually organized by the central administration. By our experience, during the events it is possible to involve academics with this topic proving the advantages and demystifying the supposed difficulties. On the other hand, efforts are made to change the internal rules, allowing the programs to be more flexible and the faculties to work in different research groups or departments. We are also trying to run in a new structure: one of the USP units does not have departments, and the faculties are organized by non-permanent subjects.

Finally, only the interdisciplinary research groups and graduate programs can get direct funding from the University. The same approach is made by the main research funding agencies like FAPESP and CNPq (Ministry of Science and Technology) that prioritized mainly interdisciplinary groups for long term support with large amount of resources.

Interdisciplinary Research & Education in China: Achievements & Challenges

Shiyi Chen

Dean of the College of Engineering
Peking University (China)

In China, interdisciplinary research and education began in the 1950's, with vigorous development in the early 1980's. Until now, it has made great progress and has worked out a set of unique development models. At the macro level, the state council has issued a series of developmental strategies and policy initiatives and carried out corresponding nation-wide project platforms as stimulation. At the micro level, there are all kinds of interdisciplinary research and education organizations in national scientific research institutions and research universities to form the operational mechanism.

1. National Strategies

1.1 Policy initiatives

In 2006, the State Council issued a “National science and technology development plan in medium and long-term (2006–2020).” In this programmatic document which guides Chinese science and technology development, it states: 1) The multidisciplinary intersection is one of the main features of future science development in terms of disciplinary development. We need to cultivate the growth of new interdisciplinary subjects. 2) It calls attention to support new interdisciplinary research and education, more specifically, to strengthen infrastructure platform, to reform managerial mechanism, to construct national laboratories and other incubators that will be equipped with top research talent and so on.

Other related documents include the “PRC Scientific and Technological Progress Act” and other legal provisions, and “the 11th Five-Year Development Strategy” stipulated by the National Natural Science Foundation. They have all mentioned the importance of interdisciplinary research and education. In general, China has recognized the importance of interdisciplinary research and used policy tools to plan out future development as a whole.

1.2 Project measures

The specific research project is vital to interdisciplinary research. China’s “Science and Technology Project” is an important mechanism. It consists of the Basic Research Project, the National Science and Technology Supporting Project, the High Technology Research and Development Project and so on, all of which contribute to the development of interdisciplinary research.

For example, the Basic Research Project includes the National Natural Science Foundation and the 973 Project. Among them, the National Natural Science Fund Committee selected 13 comprehensive and interdisciplinary fields to enjoy prioritized support. The “973 Project” also identified and emphasized interdisciplinary research. Therefore, interdisciplinary research

identified can get more funding and attract a high-level research team, and follow the principle of “unified management and integrated resource” in the course of the study, it can widely integrate and coordinate resources from government, academia and industry.

2. Interdisciplinary Research and Education Achievements

2.1 Research

China’s interdisciplinary research is mainly conducted through major scientific research projects. Among these, more than 70% are undertaken by comprehensive research universities. In general, interdisciplinary research organizations in Chinese universities have three types:

1) Interdisciplinary research organizations under the government approval
“Owned by government, run by university” can well describe this kind of organization. It undertakes major scientific research projects initiated by the government. This kind of interdisciplinary research organization is generally affiliated with a school or a department; the school or department is in charge of its management and is responsible for coordinating the research task. Take Tsinghua University as an example, it currently has 123 such research institutions, most of which carry out interdisciplinary research.

2) Independent interdisciplinary research organizations set by universities
This type of Interdisciplinary research organization can either rely on one school or department, or is not affiliated with any schools or departments. It is autonomous and can bring together related schools or departments to conduct cooperative research.

In 2000, Zhejiang University set up the first independent interdisciplinary research center, Micro System Research and Development Center, and 6 out of the school’s 21 departments are engaged in interdisciplinary research coordinated by it. In 2006, Peking University set up the Frontier Interdisciplinary Research Institute to carry out interdisciplinary research related to high-tech science. Currently, it has 9 research centers. In the meantime, PKU established the Molecular Medical Research Institution. It follows the principle “from molecular to people.” The multidisciplinary integration and dual focus both on research and application features its uniqueness. With core purpose of solving major biomedical difficulties to improve the wellbeing of Chinese citizens, it also cultivates “innovative, comprehensive and interdisciplinary” talents. Moreover, in 2010 Tsinghua University established the Cross Information Institute, which is the first teaching and research unit dedicated to the study of cross information science.

3) Interdisciplinary organizations co-founded by universities and external entities
This kind of interdisciplinary organization is co-founded by universities and external independent entities, mostly from the business sector. It usually becomes the research base of large enterprises or a campus-enterprise joint entity. For example, Tsinghua University has 102 campus-enterprise research institutions. This kind of institution is also involved largely in the interdisciplinary research.

2.2 Graduate Education

In recent years, interdisciplinary graduate training of our university has made great progress,

mainly reflected in the following aspects: Firstly, the idea of interdisciplinary graduate education has appeared and showed a tendency to grow. Many research universities, especially the “985” universities, have attempted to carry out interdisciplinary graduate education and training in environment, biomedicine, life science and language cognition fields.

Secondly, the establishment of various interdisciplinary research organizations has paved the road for the further development of interdisciplinary graduate education, for it provides the organizational and managerial basis for interdisciplinary training. Also, the merger of universities originating from the 1990’s forms many comprehensive universities with many relatively complete disciplines, which laid the foundation for interdisciplinary education.

Thirdly, in the latest “Degree Granting and Talents-nurturing Discipline Catalogue (2011)” carried out by MOE, the number of first-level disciplines increased greatly, whereas the second-level disciplines decreased. The State encourages universities to set new interdisciplinary majors in the range of first-level disciplines according to social needs.

Next, in graduate school enrollment, we encourage students to choose interdisciplinary courses; we allow a doctoral supervisor to recruit students from different disciplines should the prospective students meet the requirements. As for the interdisciplinary program itself, we tried out the combination of tutor supervision and collective training to form a new model of interdisciplinary education. We also require students to take a certain number of courses that are multi-disciplinary. Even for regular graduate students, we require them to take several courses outside their majors.

Last but not the least, we perfected the supportive system of interdisciplinary graduate education, such as facilitating the relative research for the rapid development of interdisciplinary research helps the execution of interdisciplinary education; We also began to develop multi-forms, multi-levels, and multi-types of undergraduate interdisciplinary programs.

3. Challenges in Interdisciplinary Research and Education

As for interdisciplinary research, existing challenges in our country mainly consists of: Firstly, the coordination mechanism at the national government level for science and technology resource allocation is still not perfect, with poor communication between departments, and lack of cohesion in major scientific and technological projects. Our research funding compared with major developed countries still seems very insufficient, and the structure for research investment still needs to be improved. For example, the ratio of basic research investment is too low.

Secondly, at the university level, there are inevitable resource competitions between interdisciplinary research and single subject research. At present, the science and technology resource allocation mode carried out in colleges and universities is still based on the relatively solidified single mature disciplines. When new research areas do not belong to the existing discipline category, they are easily neglected and excluded.

Thirdly, for interdisciplinary research organizations themselves, they lack first-class academic leaders and highly qualified research teams. And, the traditional “campus-faculty -department”

three-class academic organization structure is not compatible with the flow of interdisciplinary scientific research personnel. In this academic organization system, disciplinary boundaries are very clear, and there are barriers and competition between different disciplines. Teachers still belong to a certain department, and without certain permission, they cannot realize free flow as their will, which without a doubt could harm interdisciplinary research in the future.

In interdisciplinary graduate education, at present, existing challenges in our country mainly consists of the following: Firstly, the Graduate Subject Catalog designed and published by MOE neither sets interdisciplinarity apart nor leaves spaces for the potential interdisciplinarity in the future, which would restrict the development of interdisciplinary education.

Secondly, university organization and management systems may hinder the development of interdisciplinary education to some extent. For one thing, our universities organize and set schools or departments based on the first-class disciplines in the Graduate Subject Catalog, therefore, there are many schools and within each school, the major is divided to detailed. For another, most of our universities form a university- school- department three-level management system based on disciplines. The universities are used to regard schools as the basic units for policy making, resource allocating, personnel management and evaluation. Therefore, it may ignore interdisciplinary development consciously or unconsciously.

Thirdly, the traditional single-discipline education mode may affect the development of interdisciplinary education. For example, there are not enough graduate supervisors with rich interdisciplinary teaching and research experience; and there are only limited interactions, cooperation and joint training programs among different supervisors. In terms of degree granting, it is still the custom to apply single-discipline thinking to the evaluation of interdisciplinary research outcomes or to the review the interdisciplinary dissertations.

Interdisciplinary Learning in Graduate Education and Research

Noreen Golfman

**Dean of Graduate Studies, Provost and Vice President (Academic) pro tempore
Memorial University of Newfoundland (Canada)**

The Canadian landscape of interdisciplinary research and education is a forest of diversity. Canada lacks a national department or ministry of Education. We are unusual for an OECD country in this regard. Responsibility for education, which is publicly funded, falls to the regions, specifically to the provinces which receive allocations for education in the form of transfer payments. Provinces are more or less free to administer that allocation whichever way they wish. Provinces also oversee their own quality assurance boards and assessment/review processes.

Consequently, as with other areas of post-secondary education curricula, there is no national model for interdisciplinarity in Canada. Variations exist from sea to sea to sea. There is, however, a remarkable amount of consistency in the kinds of graduate programs that identify themselves as interdisciplinary. Canadians find order and good government appealing. We are nothing if not reliable. Not surprisingly, then, our programs aim for a certain tacit uniformity, even while they are tweaked differently. So it is that the programs tend to fall broadly into two categories: those that are stand-alone, as interdisciplinary master's and doctoral programs without defined subject areas, and those that bring together a number of specific disciplines to define a unique field (e.g. biopsychology; ethnomusicology; computational and systems biology; engineering and management). The former group tends to report directly to the Dean of Graduate Studies while the latter reports to one or more faculty deans, appropriate to the subject area.

The Canadian Association for Graduate Studies serves an important function in bringing graduate student leaders into conversation with each other to share best practices and solidify expectations and standards across the country. We keep an eye on each other in this way. We are too small a country not to. For at least a decade we have been convening with a view to how best to accommodate interdisciplinary studies into our universities. While interest in and support for interdisciplinary graduate programs has strengthened in this period, with few exceptions the ease with which they can be deployed remains as vexed as ever. Institutions have trouble budging from fixed discipline-based positions. Institutional infrastructure—the foundational ways departments and faculties are constructed—rests on a discipline-based model. Our university leaders usually give a lot of lip service to interdisciplinary studies but have trouble carving autonomous budgets for such programs from their academic envelopes. They are more like stubborn, cranky elders who cling to their fetish objects long after they are capable of producing pleasure.

Arguably, deans of graduate studies have had the greatest influence at the institutional level in promoting interdisciplinary learning. Overseeing university-wide programs, graduate deans often more easily see the value in cross-pollination. And it is deans who can irrigate the system, even without resources, to generate new approaches to scholarship. In Canada, influence is also

extremely important from our national funding agencies. The Tri-Council, as it is called, sets the tone for inter- and multi-disciplinary research, inviting such scholarship through special funding packages awarded to the most innovative teams of researchers. Here, for example, is the Social Sciences and Humanities Research Council (SSHRC) on its partnership grant:

Partnership Grants support formal partnerships between academic researchers, businesses and other partners that will advance knowledge and understanding on critical issues of intellectual, social, economic and cultural significance. By fostering mutual co-operation and sharing of intellectual leadership, the grants allow partners to innovate, build institutional capacity and mobilize research knowledge in accessible ways.¹

Inter- and cross-disciplinarity are implied. Here, too we see the increasing influence of the private sector on such research. Expectations are growing that solving the world's problems—social and material—require many experts, from within and beyond the academy. Ultimately, the real drive to develop interdisciplinary approaches to learning comes from our students, those multi-tasking, finger-texting, attention-challenged conduits for and vessels of information. In Canada, at least, it is graduate students who have pushed for interdisciplinary programs to feed their intellectual appetites; when and where we have been wise we have nourished them.

Einstein is often cited for having famously said “We can't solve problems by using the same kind of thinking we used when we created them.”² Any self-respecting dean of graduate studies well knows the value of interdisciplinary research, and the vitality such an approach to problem-solving brings not only to a particular program but to the university at large, and beyond. The benefits have yet to be fully measured, however. Resistance still exists among traditionalists, and there are many, in Canada. A major obstacle, beside sheer monodisciplinarianism, is unevenness of crediting supervision or teaching in these programs. Most Canadian universities calculate faculty workload according to single disciplinary unit duties. Letters of appointment often define a faculty member's duties in strict terms, and so deviating from those terms to teach beyond the stated contract takes will and interest, which fortunately many faculty members do possess.

Things are changing—slowly. Canadian science and biomedical programs tend to incline more naturally to interdisciplinary studies than humanities and social sciences do. A certain myth of purity dominates those fields, but the emergence in the last few decades of legitimate research areas such as culture, film, and media studies, by nature interdisciplinary, has challenged that conservatism. Our universities would be shrewd if they followed student interests a little more closely and considered curricula change more seriously. That's where the future lies.

¹ http://www.sshrc-crsh.gc.ca/about-au_sujet/partnerships-partenariats/partnership_grants-bourses_partenariats-eng.aspx

² <http://icarus-falling.blogspot.ca/2009/06/einstein-enigma.html>

Walking on Eggshells—Navigating Interdisciplinary Graduate Research in Australia

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Because interdisciplinary research can have an array of different meanings, a broad definition has been applied in the context of this paper.

*Interdisciplinary research integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines to solve problems whose solutions are beyond the scope of a single discipline.*²

In this paper, interdisciplinary research in Australia will be addressed in the context of national structures and challenges as well as be examined through the eyes of a recent graduate from an interdisciplinary research program.

National Context

Australia, like most developed nations, has a national research agenda with excellence at its core. Assessment of university research outcomes is conducted via Excellence in Research Australia (ERA), a performance measure informed by the equivalent research assessment exercise originating in the United Kingdom. In ERA, research outputs are assessed in 22 fields of research (FoR) which are largely comprised of traditional single disciplines. The behaviour that is driven is that interdisciplinary research is categorised under a single, primary discipline. Thus, as a result of the predominantly single discipline categorisation of FoR, interdisciplinary research is not easy to capture.

This categorisation by FoR permeates the major national grants schemes under which research proposals are evaluated by disciplinary panels. Interdisciplinary proposals that span disciplines and use mixed methods are typically evaluated by the primary discipline nominated and may fail to be understood or valued by the panel. Driving grant allocation via these practices tends to discourage applicants from submitting such interdisciplinary proposals and, once submitted, may disadvantage their success.

As formation of disciplinary silos tends to be unintentionally driven by national agendas and practices, this trickles down to affect institutional agendas which, in turn, tend to support the same behaviours. The consequence of this behaviour can be that interdisciplinary research is not valued according to the maxim “if it can’t be measured, it doesn’t have value.” Institutions themselves need to make a conscious decision to strategically invest in interdisciplinary research strategies in order to achieve successful interdisciplinary outcomes. To justify this investment

¹ With thanks to Dr. Johannes Luetz for discussions on the graduate researcher perspective. <http://www.ies.unsw.edu.au/our-people/dr-johannes-luetz>

² See http://www.nsf.gov/od/iaa/additional_resources/interdisciplinary_research/definition.jsp

decision, they need to determine the value of interdisciplinary research to their institution. In the area of graduate research, national standards can also impact on candidates choosing to do interdisciplinary research and on how the outcomes are examined. As discussed, most institutions promote research excellence and this is what attracts candidates. Given that interdisciplinary research tends to be more difficult to capture and assess, it often does not have the visibility that is achieved by traditional single discipline research projects.

Australian thesis examination is an example of how national assessment practices may impact on PhD candidates choosing to conduct interdisciplinary research or on whether they survive the experience. Thesis examination in Australia is a robust review process that typically involves appointment of two or three independent, external examiners. This approach is unique and can be a challenge for theses that result from interdisciplinary projects. Finding examiners either with interdisciplinary expertise or those within single disciplines who are sympathetic to the interdisciplinary approach can be problematic.

Perspectives of a Graduate Researcher

An interview with a PhD graduate who recently completed his studies at UNSW Australia was used in preparing this paper. The PhD topic of the graduate was *Climate Migration: Preparedness Informed Policy Opportunities Identified During Field Research in Bolivia, Bangladesh and Maldives*. The research involved mixed methods approaches and required an understanding at appropriate depth of several disparate disciplines including climate science, law, social science and development studies. The key challenges encountered related to the need to have a deep understanding of multiple disciplines, the sheer volume of learning and the continual need to keep up with the knowledge and skills required in multiple fast moving research disciplines. The statement that resonated most during the interview was that doing interdisciplinary research was “like walking on eggshells, wondering whether the research would satisfy the experts across all of the disciplines spanned.”

Other challenges to the graduate that were noted included that it was necessary to form multiple networks and navigate multiple research cultures. Close mentoring in the early stages is required to support candidates grappling with this complexity and if candidates are not self-motivated they may experience significant delays in their research.

While there is a strong case for more investment in interdisciplinary research due to, as eloquently stated by the graduate, “its capacity to provide a more comprehensive analysis of complex global issues,” the perception was that a higher value is placed on research with a focus on excellence measured by traditional research metrics compared with that producing “public good” outcomes.

The promise that interdisciplinary research delivers on is that the approaches to solving complex research problems are more holistic and provide more comprehensive and informed outcomes. While clearly not suited to all research problems, interdisciplinary research approaches have the potential to be more broadly applied to many areas that are traditionally focussed within single disciplines. The challenges are significant, and improved education and promotion of the benefits of interdisciplinary research is needed to influence national research agendas and, ultimately, challenge the global norms for measuring research success.

Promoting Interdisciplinary Endeavours in Graduate Education and Research: Observations from Hong Kong

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The Need for Interdisciplinarity

There has been and continues to be a tendency for disciplinary specialization and super-specialization in research and higher education. Clearly specialization has its advantages as scholars develop the knowledge base and strategies that allow them to solve increasingly complex problems. However, responses to complex scientific and societal problems require true collaboration among different disciplines and we need to move beyond silo-based thinking. When researchers from different disciplinary perspectives come together to tackle a research problem there is potential for novel theoretical insights and methodological innovations.

We are all familiar with the story of the six blind men and the elephant. The men were asked to describe what the elephant looked like but each man touched one and only one part of the elephant. The man who touched the leg said the elephant was like a pillar, the one who felt the tail stated the elephant was like a rope; the one who touched the trunk thought the elephant was like a tree branch and so on. The six men argued among themselves about what they touched and it was only when they worked together and integrated their different ideas and experiences that they were able to discover the truth. In this case, further research in the form of more in-depth investigation and deeper specialization by each of the blind men would not have brought them closer to the answer to the question of what they were touching. They needed to bring together their knowledge from their disparate perspectives (disciplines) to come up with a comprehensive understanding of the elephant. A horizontal integration of views was needed.

In a similar vein, we need to take an interdisciplinary or trans-disciplinary perspective to solve problems in need of a solution and it is our responsibility as providers of tertiary education to promote the notion of inter-disciplinary thinking among our students. This interdisciplinary “mindedness” needs to be promoted right from the undergraduate level and nurtured and honed through graduate study. However, this is not an easy thing to do. As noted in the background papers for this 2014 Summit, common barriers are “institutional structures that are organized by single disciplines; funding structures that discourage interdisciplinary research; and a lack of resources or expertise needed to create interdisciplinary degree-granting programs.”

Against this backdrop, this paper will focus on factors that support and those which may hinder interdisciplinarity in graduate education and research in the Hong Kong SAR. It will describe the current landscape and consider specific challenges and opportunities.

Landscape: Hong Kong Context

There are 18 degree-awarding institutions in Hong Kong and eight of them are funded by

the government. The Research Grants Council comes under the aegis of University Grants Commission (UGC) and provides the majority of funding for research and research postgraduate (MPhil and PhD) education in these eight government-funded universities. Its remit is to advise the Hong Kong government on priority areas for academic research, taking into account both global trends and local needs. The Research Grants Council in Hong Kong invites and receives, through the institutions of higher education in Hong Kong, applications for various research grants from academic staff. The allocation of earmarked research grants covers the Theme-based Research Scheme, General Research Fund, Collaborative Research Fund, Joint Research Schemes and other schemes. Two of these schemes—the Collaborative Research Fund and the Theme-Based Research Scheme privilege inter-disciplinary research. The Collaborative Research Fund (CRF) was set up to encourage research groups to engage in collaborative research across disciplines and/or across institutions with a view to enhancing the research output of institutions in terms of its level of attainment, quantity, dimensions, and/or speed.¹ In 2013/14, The University of Hong Kong (HKU) received the highest number of CRF awards (29 awards) and the highest amount of funding (HK\$23.404M²) among the eight institutions. On the other hand, the Theme-based Research Scheme (TRS)³ funds collaborative research on topics that are key to the development of Hong Kong and beyond. The selected themes necessitate interdisciplinary collaboration and relatively large grants are dispersed after a rigorous peer-review selection process. The three themes covered in the most recent round of TRS include (i) Promoting good health; (ii) Developing a sustainable environment; and (iii) Enhancing Hong Kong's strategic position as a regional and international business centre. HKU academics play a significant role in the four recently funded projects and will co-ordinate three of them.⁴

Landscape: Institutional Context (The University of Hong Kong)

Excelling together through interdisciplinary research has long been a goal of HKU as it seeks to develop strategically relevant research themes. Since 2004, the University has been identifying themes of current or potential strength for strategic development to maximize the impact of its research. These themes build on expertise and interests that cross disciplines—utilizing the synergies that such collaborations can bring—and address issues of importance to the community here in Hong Kong and Greater China as well as around the world. The current 16 strategic research themes⁵ and five emerging themes come under the following five strategic research areas: Community, Biomedicine, Environment, Frontier Technology and China, which both necessitate and afford trans-disciplinary research.

HKU also encourages interdisciplinary research and some doctoral students are jointly supervised by academic staff from two different departments or faculties (Schools). For example, there is joint supervision of students by academic staff in the Faculties of Social Sciences and Education (children with autism), Engineering and Medicine (biomedical Engineering),

¹ Information extracted from the RGC's website (<http://www.ugc.edu.hk/eng/rgc/fund/grants.htm#d>)

² Excluding on-costs

³ Information extracted from the RGC's website (<http://www.ugc.edu.hk/eng/rgc/theme/theme.htm>)

⁴ The 3 projects coordinated by HKU have been awarded a total of HK\$184.54M for a period of 5 years, representing 90% of the total funds.

⁵ *Community* (Ageing, Neuroscience, Public Health, Sciences of Learning, Food*, Law, Literature, Language*); *Frontier Technology* (Computation and Information, Drug, Genomics, Integrative Biology*); *Biomedicine* (Biomedical Engineering and Nanotechnology, Cancer, Development and Reproduction, Infection and Immunology, Stem Cell and Regenerative Medicine*); *China* (China Business and Economics, China-West Studies, Cotemporary China); *Environment* (Clean Energy, New Materials, Earth as a Habitable Planet*).

Engineering and Science (materials for energy applications), Dentistry and Science (dental public health), and Architecture and Education (school design). Interdisciplinary thinking is also encouraged through course and experiential requirements for doctoral students.

Challenges and Opportunities

We know that multi-disciplinary research is pivotal for innovation. When individuals from different disciplines work together, more can be accomplished than if they work alone. Further, when researchers from different disciplines integrate perspectives, methodologies and data they are better primed to enhance our understanding of phenomena and solve real-world problems than groups of researchers from one discipline (Trehwella, 2009).⁶

There are many challenges associated with promoting interdisciplinary thinking. First, universities are organized into departments and schools/faculties and this promotes a disciplinary mentality. Second, recruitment, tenure and promotion policies do not typically favour interdisciplinary research. Third, grant awarding agencies do not facilitate interdisciplinary research as the peer review system tends to rely on experts from a single discipline (Trehwella, 2009). Fourth, interdisciplinary journals are less common than discipline-specific ones. Higher education institutions are in a unique position to train the next generation of scholars to value and engage in interdisciplinary research. Students need both solid discipline-based knowledge as well as the opportunity to work in different disciplines and both undergraduate and postgraduate levels. That stated, an “individual” interdisciplinary researcher is not common (Trehwella, 2009) but it is more likely that teams of researchers from different disciplines will work together.

According to Davoudi,⁷ we have to overcome “disciplinary tribalism” and move beyond both multidisciplinary (multiple disciplines coming together but each working primarily with their own framings and methods) and interdisciplinary (occupying the spaces between disciplines to build new knowledge) approaches to trans-disciplinary approaches (creating a cross-road in which different disciplines intersect and influence each other).

Clearly there is much value to promoting both interdisciplinarity and trans-disciplinarity in graduate education and research. At an institutional level, we can provide the conditions to promote high quality interdisciplinary research and dismantle barriers which hinder it. However, we still have to gain a better understanding of how we can use best technology to support interdisciplinary communication and collaboration and how we can effectively facilitate trans-disciplinary team work.

⁶ Trehwella, J. (2009). *Multi-disciplinary research – an essential driver of innovation*. Paper presented at the Australian Financial Review Higher Education Conference.

⁷ Davoudi, S. & Pendlebury, J, 2010, Evolution of planning as an academic discipline, *Town Planning Review* 81(6):613-644

Table 1

Drivers and barriers for interdisciplinarity in research

	Internal factors	External factors
Drivers	<ul style="list-style-type: none"> √ Strategic Research Themes √ Award of Post-doctoral Fellows √ Award of internal research grants 	<ul style="list-style-type: none"> √ Funding agencies (Collaborative Research Fund, Theme-Based Research from the RGC) √ Reputational incentives (League tables in terms of number of projects funded and amount of funding from funding agencies)
Barriers	<ul style="list-style-type: none"> ▶ Disciplinary silos (organization into departments) ▶ Lack of funds ▶ Institutional culture ▶ Methods of assessing and rewarding research productivity ▶ Lack of acceptance among peers about the value of interdisciplinarity 	<ul style="list-style-type: none"> ▶ Peer review process for grants and journal publications (low priority to inter-disciplinary projects)

Source: Adapted from Improving Business Environmental Performance: Corporate Incentives and Drivers in Decision Making. p. 33-34. DEFRA 2006.

A Formal Approach to International Studies Focusing on Existing International Strengths at Indiana University

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Interdisciplinary programs and degrees have always been unique as they cross over into many areas of study calling students and faculty to appraise and think about materials in various ways. These interdisciplinary programs are a means of joining and connecting disciplines in new and unique ways that facilitate stronger connections between disciplines that might have little to no previous formal connection.

When, in 1901, Professor Fred Atkinson of Indiana University was appointed the general supervisor of education in the Philippines, this began IU's long history of international activities and studies (School of Global and International Studies, History). Indiana University for many years has worked to create and expand programs and departments that promote international studies in as many disciplines as possible. This interdisciplinary focus is seen strongly in the newly established School of Global and International Studies at Indiana University.

The School of Global and International Studies (SGIS) within Indiana University College of Arts and Sciences continues and strengthens this international focus by facilitating over twenty undergraduate degrees and over twenty-five graduate programs that will prepare students for the twenty-first century. For many years Indiana University-Bloomington has taught over seventy different languages and has many different schools and resource centers that focus on understanding and celebrating many world cultures. These languages include Norwegian, Dari, Mongolian, and Uzbek among many others. Departments and Centers have also been created to allow students to study different cultures. These centers include the Russian and East European Institute, the Center for Latin American and Caribbean Studies, and the Inner Asian and Uralic National Resource Center. Since the advent of the Cold War, Indiana University has worked to strengthen and establish programs that align with current geopolitical concerns of international importance. Thus, it was a natural evolution at Indiana University to create the School of Global and International Studies.

Begun in 2010, the New Academic Directions committee worked to create strategic changes to all of Indiana University's campuses. The plan called for academic excellence, better efficiency, innovation, and collaboration. The committee, whose report was presented to the Board of Trustees of Indiana University in 2011 called for some major strategic shifts at Indiana University. Among these shifts were:

- Investing strategically in existing and new programs;
- Reducing support for lower-priority programs;
- Encouraging innovative alignments of academic units;
- Seizing opportunities for efficiency;

- Reducing administrative barriers for excellence and innovation;
- And enhancing revenue strategically and cost effectively (New Academic Directions Committee 1-2).

Out of this report came many large responses including the School of Global and International Studies.

In “New Academic Directions,” Indiana University sought to create strong partnerships and collaboration between professional schools and the College of Arts and Sciences to create SGIS. SGIS was established in 2012 as a means of focusing much of the talent that was already present at Indiana University. SGIS is more than another research center at Indiana University; it was formed as its own academic unit within the College of Arts and Sciences. Indiana University recognized that globalization and interdisciplinary research are important aspects of twenty-first century scholarship and it wanted to bring together the energy, scholarship, and expertise of the faculty at Indiana University to create an interdisciplinary unit that recognized this important world-view. The establishment of SGIS allows IU to both consolidate international research and scholarship but also allows IU to expand its academic, educational, and research undertakings in a meaningful and deliberate way. SGIS brings together more than 350 core and affiliated faculty from schools including the College of Arts and Sciences, Jacobs School of Music, School of Education, Kelley School of Business, and IU’s 11 Title VI international area study centers to create a unit that addresses the world’s most important geographical, political, economic, and social problems.

Indiana University’s president, Michael McRobbie, noted in 2012 that there is not a single part of American society, which is “not affected by global forces and developments” (“IU Trustees”). With the creation of SGIS, Indiana University is working to create a school where students can prepare to participate in a society that is influenced by global and international events. As McRobbie goes on to say, “The School of Global and International Studies will prepare [Indiana University’s] students for the competencies of the 21st century...and enable them to think more deeply about issues that cross national boundaries” (“IU Trustees”). SGIS will prepare students of many disciplines to understand and function in a world that increasingly has issues and ideas that cross international boundaries and affect everyday life in ways that were completely unanticipated in previous years. Indiana University already has an incredibly strong history in international and global studies and SGIS was a natural continuation of this long tradition.

As SGIS was only approved by the Indiana University Board of Trustees in 2012 there is still much to be done. However, a great deal of progress has already been made and many national and international leaders are involved in this new school. Both Senator Richard Lugar and Representative Lee Hamilton, long-time politicians with strong international political experience have joined the faculty of SGIS. The groundbreaking for the new SGIS building and inauguration of the new school was held on April 29, 2013. The building is expected to take two years for construction and will be ready for the 2015-2016 academic year. SGIS also has a well-respected dean that brings a wealth of knowledge from his two decades of experience in diplomatic and foreign affairs positions. Lee A. Feinstein is the former ambassador to the Republic of Poland and will be the inaugural dean of the School of Global and International Studies.

The new School of International and Global Studies is a perfect example of an interdisciplinary approach to higher education. It is designed to take advantage of the wealth of expertise at Indiana University and take advantage of the long tradition of international research at IU. The “New Academic Directions” report from 2011 set the stage for a school that encourages innovative alignments of academic units and increases the efficiency of the entire university. This interdisciplinary program allows Indiana University to become a leading institution that utilizes cross discipline research and teaching in ways that prepare students to function and thrive in a world that is increasingly interconnected. With increasing globalization and intercultural communication it is important for students to receive a well-rounded and cohesive education. The interdisciplinary nature of the School of Global and International Studies is well suited for this endeavor.

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2: Creating an Institutional Culture that Values Interdisciplinary Learning

Benefits of Supporting Interdisciplinary Learning and Research: A University of Manitoba Perspective

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The University of Manitoba

The University of Manitoba is a member of the U15 group of Canadian research-intensive universities and the only research-intensive university in the Province of Manitoba. The population of the Province of Manitoba is about 1.3 million people; 50% of that population lives within a 20 km radius of Winnipeg, which is home to the University of Manitoba. The University is a publicly-funded institution with nearly 30,000 students, 3,800 of which are graduate students. Although the University was created in 1877, the Faculty of Graduate Studies wasn't created until 1947 (67 years ago). Over the initial years there was a proliferation of discipline-based master's and doctoral programs. There are 78 departments/units at the University that offer graduate programs; all offer a master's program but only 60% have doctoral programs.

The “Tribe” Mentality

Those of us pursuing graduate studies in the 1980's know all too well that we were educated in “silos”—discipline-specific departments. Angela Brew (2008) follows Becher's idea and likens the disciplinary “silos” to “tribes”—each with its own tradition and culture. Brew (2008) notes, “the tribe becomes self-sustaining with a relatively distinct academic, social and cultural identity.” She goes on to assert “students are socialized into the culture in order to be accepted into the tribe.” Graduate deans are well aware of the cultural diversity and norms across an institution's graduate programs. While this culture is still common, many graduate schools (including the University of Manitoba) have facilitated interdisciplinary studies. The literature uses two other terms to refer to interdisciplinarity, *viz.*, transdisciplinarity and multidisciplinarity—while there are more than nuances between these terms, interdisciplinarity is probably the best term.

Why Interdisciplinary Studies?

The need for interdisciplinary studies is obvious. Many of today's research topics are much broader than a single discipline, for example, human rights, material science, or medical research. While epidemiologists argue over the merits of traditional mammography, physicists and electrical engineers are working with oncologists to develop new techniques to differentiate breast tissue. While some of these interdisciplinary studies have given rise to new “disciplines,” (such as bio-medical engineering in the latter example), many still remain as interdisciplinary studies.

Interdisciplinary Studies at The University of Manitoba

Of the 3,800 students enrolled in graduate studies at the University of Manitoba, approximately 50 are enrolled in an individual interdisciplinary (master's or doctoral) program, known as an “IIP.” An IIP allows a student to pursue research that does not fit within a traditional

“silo” or “tribe.” To formally enroll in an interdisciplinary program (either master’s or doctoral), the student’s proposed program of study must span at least two departments and the proposed program of study must not be possible under any one of the associated department’s supplemental regulations. To facilitate the administration of an interdisciplinary student’s program, s/he is assigned a home department—typically the home department of the primary advisor. Since co-advisors are common for interdisciplinary students, one of the co-advisors is designated as the primary advisor. IIP students at one time were administered at the faculty level as opposed to the departmental level. Unfortunately, not associating an IIP student with a department often resulted in these students being overlooked for departmental-based awards, which constitute the majority of graduate awards at the University of Manitoba. There was a certain irony associated with overlooking these students as the GPA requirement for admission to an IIP program is (with only a few exceptions) higher than that required for admission to a non-interdisciplinary program.

An IIP student forms a “bridge” between the co-advisors; this facilitates a sharing of discipline-specific perspectives that benefits the student and the advisors. There is a richness that results from this “cross-fertilization” of perspectives that can lead to new approaches and perspectives to problems. In some cases an IIP student is part of a large team of investigators tackling a significant problem from a variety of perspectives. The payoff for an institution can be significant when there is a major breakthrough.

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Promoting Interdisciplinarity in Europe: The Role of University Leadership

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The Changing Nature of Research

Earlier this year the 3rd annual meeting of the Global Research Council (GRC) was held in Beijing. The resulting Statement of Principles for shaping the future focuses on the overall priority of supporting the next generation of researchers, including thinking about the appropriate skills and competences needed, about ways to promote socially responsible research and on how research will contribute to and be transformed by a shifting social, economic, political and environmental global context. Further development of support to interdisciplinary research is considered one of the main ways in which these objectives can be reached. Similarly, at the European level the new EU funding programme 2014–2020 (Horizon 2020), with a focus on excellent science, industrial leadership and global societal challenges, also attaches greater importance than in the past to promoting interdisciplinarity, as do many National Research Councils in Europe.

This new context also impacts the way in which knowledge is produced and disseminated, and encourages the shifts in knowledge production from “mode 1 to mode 2” described by Gibbons, Nowotny, et al. already in 1994 (*The New Production of Knowledge, The Dynamics of Science and Research in Contemporary Societies*) which involves changes in the way in which research is conducted from academically- to contextually-driven, from investigator-initiated to end-user-focused, and from mono-disciplinarity to inter-disciplinarity.

The Modernisation of Universities

In response to global challenges and greater competition, European university systems and universities have gone through massive change in the last 10 years. At the system level this includes mergers and other forms of institutional consolidation that often seek to improve critical mass in research and innovation and increase capacity for interdisciplinary thinking. One prominent example is the merger of three very different Helsinki universities: the University of Art and Design, the University of Economics, and the University of Science and Technology, into what has become Aalto University.

Over this period European universities have also been granted greater autonomy and in return have been encouraged to reflect on their role and review their mission, their delivery and management in response to the demands of knowledge societies and economies. There is a greater focus on innovation and on universities’ capacity to react quickly and efficiently to the demands placed on them by society. These changes have also meant rethinking internal structures building up new management and decision-making structures and reconsidering career and reward systems to support interdisciplinarity and mode 2 research.

The challenges of promoting and ultimately embedding interdisciplinary approaches at the institutional level are multiple, be it lack of adequate infrastructures in the broadest sense, such as the silo organisation of departments, the content of curricula at the bachelor's, master's, and doctoral levels, the content of textbooks, the organisation of professorships, the mono-disciplinary focus of high-impact journals, etc., as well as scepticism and resistance from the academic establishment or the fact that the majority of scholars have backgrounds in a single discipline.

At the same time, looking forward, strengthening interdisciplinary approaches will be crucial for addressing ever more complex research questions and for the future careers of doctoral candidates and young researchers, whether they remain in academia or for the majority who will either pursue research careers in companies or take up high level careers in the public and private sectors.

The Role of Leadership: Examples of the type of initiatives being developed in European universities

Reconsidering institutional mission, strategies and policies – for example further differentiating institutional missions to include commitment to local/regional community engagement or addressing societal challenges. Recruitment policies may also need to be adapted, career paths identified and specific research assessment criteria developed for researchers working in an interdisciplinary or multidisciplinary context, not to forget opportunities for inter-institutional cooperation.

Promoting structures and processes that support interdisciplinary work – and that can also help shape “institutional cultures” e.g., large multidisciplinary schools or joint doctoral training centres, even if interdisciplinary work always remains challenging and requires a strong human interface.

Emphasising the importance of “communication” – interdisciplinary work needs a special form of communication, based on the ability to communicate beyond the boundaries of one's own field, to try to understand more than one field and also develop the ability to communicate between fields and to explain scientific work to a larger academic public.

Providing incentive funding – while it is often still difficult to fund interdisciplinary research and a lack of reviewers is a further challenge (given that disciplinary reviewers may tend to assess harshly due to a mismatch of expectations on depth and breadth of theory and methods), there are many examples of universities that have developed internal funding mechanisms that promote interdisciplinary approaches:

Using national targeted funding initiatives – such as Germany's “Excellence Initiative” or the French “Idex.”

The Importance of Research Training and the Key Role of Doctoral Schools

Doctoral schools and other structured doctoral programmes now exist in one form or another in all European universities. This has been one of the most significant developments in European higher education in the last decade. These structures take various forms but in general play

a crucial role in promoting interdisciplinarity. Many are, indeed, interdisciplinary in scope, organised on a broad faculty basis, facilitating dialogue between disciplines, opportunities for students to work in cross disciplinary teams and in common projects and encouraging national and international exchange.

Concluding Remarks and Open Questions

While universities and research funders are increasingly aware of the importance of promoting interdisciplinary research there are many open questions both at institutional level, and specifically related to doctoral education where concerns include the extent to which interdisciplinary doctoral projects attain the necessary depth, whether there is enough time and whether interdisciplinary approaches need to be introduced well before the doctoral cycle. Discussion also continues on the role of the supervisor who must be willing to work out of their comfort zones and the extent to which different supervisors are able to “talk” to one another, or who is in the lead. There are also questions about the recognition of such degrees by government bodies and in the labour market. Among the broader institution-wide issues that need to be addressed, questions of funding, structures, recruitments, research assessments and peer review are paramount. Last but not least, there are the invisible barriers around different disciplinary cultures and questions of parity of esteem. Overcoming these obstacles, and creating an institutional culture that will be supportive of and value interdisciplinarity requires purposeful leadership at different levels, adequate structures and processes and the appropriate financial incentives.

The Role of Institutional Leadership: Promoting Interdisciplinarity Beyond ‘Workarounds’

Denise Cuthbert
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The Paradox of Interdisciplinarity

Challenges for those seeking to engage in interdisciplinary research and research training lie in the gaps between ubiquitous rhetoric espousing the benefits of interdisciplinarity and the persistence of institutional (and governmental) structures, funding flows and cultures which reflect the primacy of disciplines. At best the latter fail adequately to recognise/reward/fund/support interdisciplinarity. At worst, they actively inhibit it. This has been described as the “paradox of interdisciplinarity” in the literature (Weingart 2000; Woelart & Millar 2013), and is well documented by scholars writing in the US, UK and Australian contexts.

The disciplines remain a powerful force in the organisation of knowledge. The structure of many—perhaps the majority—of universities reflects and further enshrines this disciplined organisation with the primary academic unit being the discipline-based or -bounded school or department. Promotion committees, grant funding (both internal and external), academies and other scholarly associations, and exercises such as research quality audit regimes, prevalent in higher education systems in the UK, Australia, New Zealand, South Africa and elsewhere, are commonly organised in terms which privilege established disciplines and push to the margins emerging interdisciplinary fields (Gläser & Laudel 2007; Genoni & Haddow 2009). In both the UK and Australia, the classification of research fields for the purposes of research quality audits provides one example of the persistence of the disciplines. As strongly evinced in the Australian higher education sector (Bammer 2012), even in contexts in which the benefits of interdisciplinarity (for innovation and impact) are avowed and putatively supported by government, the hegemony of disciplines persists.

Workarounds

Various “solutions” to this problem (or workarounds) have been developed with different degrees of success. A common approach in Australian higher education, evident in the pre-1980’s universities in which discipline silos are most evident, is the retro-fitting or over-laying of interdisciplinary programs, commonly called centres, onto or over the discipline-based school or department structure. In the HASS fields, this workaround emerged in the mid-1980’s as a response to the emergence of theoretically-driven new fields of studies which in many cases were not welcomed in the disciplinary-based departments which had fostered their emergence in other higher education sectors. A good example of this development is the growth of centres of cultural studies and comparative literature alongside traditional departments of English, which in many cases hunkered down to a more trenchant focus on “English” (to avoid the de-stabilising influence of continental theory) and “literary” texts (to exclude the range of texts which cultural studies sought to subject to analysis). Another example is the emergence of Centres for Women’s Studies which were established by feminist scholars from a range of disciplinary backgrounds—

these programs were sometimes “housed” within departments of history, English, or sociology, or developed as standalone centres. In either case, existence was precarious. Staffing was often managed on what became known as the “ladies auxiliary” model: feminist academics took on teaching duties in Women’s Studies in addition to heavy loads in their home departments. As with the Centres for Cultural Studies, the right to establish majors and hence pathways to graduate studies, and to enrol PhD candidates was hard fought and in some cases took over a decade.

In cases where flourishing centres established the funding flow through enrolments to establish their own staff base, promotion and career tracks for centre staff was also hard won. Promotion committees, dominated by discipline-based academics, were slow to acknowledge the journals in which interdisciplinary scholars published and that the work they undertook was sufficiently important to warrant advancement. For many working in interdisciplinary fields, the abiding sense is of needing to work *against the institution* in order to function, rather than being supported by it (Lamont et. al 2006).

We can do better than this...

University leaders can and need to do more to promote interdisciplinary education and research, particularly research training.

- Mechanisms for joint appointments of staff (in disciplinary home departments and interdisciplinary centres) should be facilitated and monitored carefully to ensure that .5 +.5 doesn’t = 2.00.
- Interdisciplinary programs should have the capacity to appoint and second staff.
- Appointment and promotion committees should be open to achievements outside conventional disciplinary lines. Interdisciplinary scholars should have representation on such committees.
- Undergraduate programs need to be structured so as to enable interdisciplinary or multi-disciplinary majors or study themes. Problem- or issues-based studies are ideal for this purpose and bring other learning benefits as well. This will ensure a flow-through of well-prepared candidates for interdisciplinary graduate research.
- Pathways to graduate studies need to be opened to students with backgrounds in a range of fields.
- Funding schemes specifically to support interdisciplinary curriculum initiatives and research activities need to be developed.
- University leaders should advocate for interdisciplinary studies with government research funding and auditing agencies. In the Australian example, FoR (Field of Research) codes need regular review to ensure they accurately capture emerging fields of research and concomitantly that the research of those in these fields is not per force downgraded due to inadequate classifications.
- University leaders should actively pursue collaborative research training programs with other institutions and the placement of research candidates in industry for part or the duration of their studies (as appropriate to the research program). Interdisciplinary breadth and expertise can be enhanced through collaboration.

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Accessible Excellence and Stature: The Need for Interdisciplinary Studies at the University of Johannesburg

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As well as being an institution that prides itself for its accessible excellence—after only nine years—the University of Johannesburg (UJ) has also established itself as an institution of global excellence and world class stature.

In 2013, QS (Quacquarelli Symonds) World University Rankings ranked UJ among the top 4% of universities in the world, placing UJ in 601-650 out of 16,500 universities worldwide. QS also ranks UJ among the top 1% of universities in the BRICS countries, that is Brazil, Russia, India, China and South Africa, placing 61st among this economic bloc's 6,200 universities. UJ is the first and only African university admitted to the highly respected consortium of 28 research-intensive universities in the world: Universitas 21. All of these accomplishments are important endorsements of the growing international stature of UJ.

In a major shift towards achieving an international reputation for academic and research distinction, UJ intends to invest more than R600 million over the next seven years in six Flagship Research Institutes designed to enrich and deepen its academic profile through research innovation. The strategy aims to transform UJ into a pan-African epicentre of critical intellectual inquiry and scholarship with a particular focus on interdisciplinary studies. This approach is due to decisive action of the institutional leadership from 2013 onwards.

Flagship Institutes

In a global environment that makes increasing demands on the earth's resources for energy, water, food, health, sustainability and industrial mechanisation, the University of Johannesburg aims to influence the international search for solutions through an inter- and multi-disciplinary approach. The flagship programmes have a dedicated focus on postgraduate studies. This includes a cohort of postgraduate students and postdoctoral fellows present in the institutes, visiting professors who can contribute to mentorship and supervision, and a research publication and graduate output plan. One hundred and thirty master's and doctoral students and 80 postdoctoral fellows will be supported over the next five years by the global excellence and stature strategy.

The new multi- and inter-disciplinary flagship programmes support the establishment of new qualifications. These include MPhil degrees in Sustainable Megacities, Neurocognitive Science and in Water Supply, Sanitation and Management. Others include an MSc in Sustainable Mining and Financial Engineering, an MEng in Engineering Management, and an MCom in African Leadership.

We provide some detail of the interdisciplinary programmes, and the research focus below in selected examples of the Research Institutes.

Institute for Earth Sciences

The Earth Sciences Flagship Institute seeks to provide science and engineering solutions for the continuing growth of South Africa's resources industry while at the same time developing benefits to the economy, society and the environment. The programmes are informed by the collective subject of geoscience that is divided into its sub-fields of geology, geophysics and geochemistry. The Institute harnesses the strength of interdisciplinary research that addresses the pressing environmental dilemmas that face South Africa and the world by leveraging research in Physics, Mining Engineering, Geology and Geography.

The institute will assimilate an integrated understanding of the nature and origin of some of the major and minor mineral and fossil energy resources of South Africa and their geometallurgical characteristics. The knowledge produced will be used to explore innovations that will ensure optimum and sustainable extraction of mineral resources.

Institute for Nanotechnology and Water

The establishment of an Institute for Nanotechnology and Water research is characterised as a collaborative effort that creates an intellectual environment that focuses on a multidisciplinary approach. The world-class research in nanotechnology and water purification reflects on the design and creation of functional materials, structure devices and systems and directly controls matter at the nano-level.

Research at the Institute will concentrate on solving some of the long-standing and fundamentally important problems of water purification using progressive methods. The aim of the Institute is to make the research available for publication and teaching purposes and to develop solutions through research for practical application. The goal of the Institute is to broaden the scientific knowledge base of this area of research and support the application of nanotechnology into new areas of purpose.

Institute for Sustainability and Megacities

The critical role of sustainability in Africa is based on the concept of shared values that implement connections between societal and economic progress. The future of Africa can be defined through a framework of sustainability management that initiates opportunity for wealth creation and economic opportunity thus improving the lives of ordinary people on the continent. The Institute aims to integrate various UJ faculties and their global partners in coordinating and implementing sustainability initiatives benefitting Africa's sustainability agenda, specifically in the context of urban development. Research topics range from socio-economic development to architectural, engineering and management applications—all aimed at improving the organisational bottom line by contributing to a greener planet and bettering people's lives.

The Institute for Sustainability and Megacities will be responsible for conducting internationally recognised, academically excellent and problem-oriented interdisciplinary research and teaching on environmental, social and economic aspects of sustainability.

Concluding Comments

The institutional leadership at UJ, has, through its support for the Global Excellence and Stature programme, established three key areas of performance. These are postgraduate studies, research, and innovation. In postgraduate studies, the key indicators include innovative programmes and consistently high postgraduate output, in research the key indicators are research productivity and collaboration, and in innovation these include applying a technology-driven research approach and development. All of the above provide a solid foundation for the establishment of successful interdisciplinary programmes at UJ.

Overcoming Common Barriers

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Interdisciplinary graduate programs face many challenges, which are relatively easy to enumerate. Identifying effective strategies to mitigate these challenges is more difficult, as many of these challenges are deeply embedded in the structure of the contemporary university. I will divide my discussion into two sections, one of which speaks to the challenges posed by subject-focused interdisciplinary programs (such as Public Policy, Bio-Medical Engineering or Computational Media Design) and another which speaks to the challenges that arise in individualized interdisciplinary programs, which bring together eclectic sets of disciplines appropriate to a student's specific project.

Subject-focused Interdisciplinary Programs

Fundamentally, subject-focused interdisciplinary graduate programs are perceived to be threatening to the well-being of the cognate disciplines from which they draw faculty supervisors and (potentially) students. For example, my home discipline of Political Science has experienced what many within the discipline see as fundamental existential threats from the emergence of interdisciplinary programs in International Relations, Strategic Studies and Public Policy. From the perspective of faculty members in disciplinary units, interdisciplinary programs enjoy the advantages of novelty, a more practical or problem-based approach, and, consequently, greater support from senior university administration and government.

From the perspective of disciplinary units, there are several specific ways in which interdisciplinary graduate programs may adversely affect them. This analysis presumes that faculty members are appointed to disciplinary units, not interdisciplinary programs. First, the supervisory capacity of faculty members is divided or allocated entirely to the new program; available funding for students may shift (or be perceived to be shifting) to the interdisciplinary program. This affects the capacity of the disciplinary program to accept students, and also presents a dilemma that the disciplinary unit is not given credit for the supervisory work of its members. The faculty members themselves may experience pressure from both the disciplinary and interdisciplinary program to accept students. Second, students who might otherwise have pursued disciplinary training may opt for the interdisciplinary competitor. Third, faculty members ineligible or unwilling to supervise in the interdisciplinary program perceive themselves to be less valued or of lower status than their interdisciplinary peers and consequently position themselves as 'defenders of the discipline.'

At best, administrators can attempt to mitigate these concerns, but are unlikely to banish them. Defenders of the discipline may be mollified by moves toward reciprocity in the allocation of resources. For example, interdisciplinary graduate programs not attached to an undergraduate program may fund their graduate students to serve as teaching assistants in the home disciplines of their supervisors, thereby strengthening the disciplinary undergraduate program and acknowledging the discipline's loss of its faculty members' supervisory capacity. When

interdisciplinary programs are particularly well-funded but ineligible to employ faculty members directly, they may be able to fund faculty positions in cognate disciplines, thereby strengthening both the interdisciplinary program and the cognate discipline. Even this might not be welcomed fully by the defenders of the discipline, who may resent the interdisciplinary program's ability to determine hiring priorities and influence the outcome of the hiring process itself. Certainly, universities can—and should—adjust their formulae for counting student numbers to take into account interdisciplinary supervision.

A common challenge in interdisciplinary programs (both subject-focused and individualized) is a clash of disciplinary norms for research and scholarship. The greater the intellectual or methodological span between the home disciplines, the greater the challenge. While two social sciences might be able to agree on methodology and epistemology, the same may not be true of a social science paired with a humanities discipline. When the sciences are brought together with social sciences or humanities, the challenge deepens further. These issues are best resolved through extensive discussion and establishment of common norms among faculty members supervising in the interdisciplinary program. Ironically, however, the very establishment of these norms moves the interdisciplinary program toward a form of “disciplinization” as it takes on the characteristics of a discipline (a set of shared norms governing methodology, epistemology and scholarship). It is not clear whether this should be seen as success, as interdisciplinarity is normalized, or as a failure, as the creative tension inherent in interdisciplinary research is extinguished.

Individualized Interdisciplinary Programs

Because they bring together eclectic combinations of disciplines suited to a single student's research interest, individualized interdisciplinary programs do not present the same existential challenge to disciplines as do their subject-focused counterparts.

A key challenge faced by individualized interdisciplinary programs is a tendency to conflate “interdisciplinary” with “undisciplined.” In the absence of rigorous oversight, there is a danger that interdisciplinary programs become home to supervisors cast out by their home programs, or students unable to gain admission to existing graduate programs.

Because interdisciplinary programs demand that students master two or more disciplines and navigate the methodological and epistemological differences between them, these programs must be administered with great care, ensuring that only the best-prepared students be admitted, and that their supervisors mentor them extensively through the challenging path they have chosen. The Director of an individualized interdisciplinary program should be an experienced academic administrator equipped to mediate supervisory committee conflicts and provide extensive guidance to students and committees. Common student experiences, focused on the practice of interdisciplinarity, its associated methodologies and challenges, are also critical to ensuring the rigor of the graduate experience and the preparation of students.

Conclusion

The challenges of interdisciplinary graduate programs and research are many, and are not easily addressed through administrative solutions. The situation is not entirely gloomy, however. Increasingly, interdisciplinary research has “gone mainstream.” Students enrolled in disciplinary

graduate programs are offered greater flexibility in selecting their courses, constructing supervisory committees with representation from more than one discipline, and pursuing research projects that transcend disciplinary boundaries. Arguably, this development has been largely organic, rather than driven by institutional arrangements or incentives. Simply put, as faculty members' research has become more interdisciplinary, they have become more accommodating of interdisciplinary graduate research, and barriers have, in many instances, melted away. At my institution, this gradual development has undermined the vitality of the individualized interdisciplinary program, as students with interdisciplinary projects have preferred to enroll in disciplinary graduate programs that accommodate interdisciplinary research, rather than opting for the formalized interdisciplinary route.

3: Building Interdisciplinary Degree Programs

Building Interdisciplinary Degree Programs: Administrative and Organizational Issues

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Dean of Postgraduate Research
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Nā tō rourou nā taku rourou ka ora ai te iwi.

With your food basket and my food basket the people will thrive.

The benefit of bringing together knowledge and methods of experts from different disciplines has long been recognized. While such adding together of skills—the multi-disciplinary approach—can enhance understanding around specific problems, interdisciplinarity introduces the taking of a new approach to any problem. Interdisciplinarity relates to the *integration* of two or more disciplines, with researchers *modifying* their knowledge and approaches to create a new way of approaching issues. Biochemistry, for example, is more than adding together biological and chemical expertise and approaches; biochemists have a different approach to questions than do chemists or biologists, though based within the background of those formative disciplines. An interdisciplinary approach leads to new insights, new solutions and new ways of thinking that extend knowledge and enhance problem solving. Development, and sustainability, of such approaches is then vital.

Many institutions promote the availability of interdisciplinary programmes and highlight the importance of such approaches for future society. At the same time, however, inter-disciplinary programmes frequently struggle and close. The requirements for interdisciplinary programmes mirror those of traditional disciplines: expert academics, expert technical support, access to relevant resources to support students and staff, funding and career opportunities. Too frequently, however, barriers arising from institutional structures, boundaries and funding models prevent easy access to one or more of these requirements and hence leave individuals and programmes vulnerable. If institutional boundaries prevent the recruitment of students, the accessing of research funds, the promotion of academics within such programmes or the career opportunities for graduates of such programmes then sustainability of the programme will be at risk. Further, it illustrates a situation of administrative and managerial structures dictating, and inhibiting, the direction of academic progress which should be the very antithesis of tertiary research-based institutions.

Tertiary institutions are traditionally structured around disciplinary domains—departments/schools—associated with undergraduate curricula, each with its own management structure and funding. Without due care and flexibility within such structures, interdisciplinary academics, students and programmes can fall into an unseen crevice between constituent departments. When hiring decisions, grant allocations, and support for graduate students, for example, are department-based, none may be willing to allocate a staff position to the interdisciplinary area, or to (fully) fund students or research costs in such an area for fear that such decisions will not best serve the department as an individual's teaching and/or research supervision might straddle

departments. Interdisciplinary programmes and individuals become victims of a NIMBY (not in my backyard) syndrome—while everybody agrees that interdisciplinary programmes are a valuable thing that the institution as a whole should have (and from which they can benefit) nobody wants to support or fund them within their specific part of the institution. Geology would love geography to employ an environmental science or waterways expert (and vice-versa) but will not do so themselves.

Below I discuss two ways that institutions might consider to overcome these barriers—through either breaking down existing organizational barriers or through creating new ones. Some of the opportunities and challenges presented by each are considered. In discussing these options, however, it must be kept in mind that organizational structures cannot themselves ensure the development and maintenance of programmes but can facilitate such only when there is support and buy-in from individual academics and management (e.g., departmental heads). Further sessions in this summit address more closely the issues of engaging faculty and the attitudinal shifts required in so doing.

Breaking Down Barriers

Must academic appointments be made only to a single department? Must research students have a home in a single department (that of their primary supervisor) rather than in an interdisciplinary research group? Sharing academic appointments, research grants and research students across disciplines exposes interdisciplinarity to members of all constituent departments. The challenge is, however, to ensure that individuals in such joint positions, and their research, are truly valued by both disciplines, and that these individuals are afforded opportunities within each department. The traditional institutional structure still requires the individual academic or student to have a “home” department, the unit that is responsible for financial and administrative matters (e.g., promotions). As soon as a home is designated, the individual tends to be seen as being part of that department to a greater extent. Disciplines tend to favour individuals and research that is perceived to be core to the discipline. Especially in times of fiscal constraint, disciplines will retrench and support the discipline’s core before interdisciplinary programmes. A traditional institution with departments of biology and chemistry will see such retrenchment lead to a decline in funding of biochemistry. Joint positions also place a heavy burden on those who hold such positions, as they are beholden to two “masters” and disciplines. Such positions will only be effective if they integrate across the constituent departments, for example creating research teams across the departments, rather than simply having a person fill two half-time but distinct positions.

Similarly for doctoral studies in interdisciplinary studies it is not sufficient just to have a supervisory team comprised of members of multiple disciplines. A thesis in an interdisciplinary domain must take an interdisciplinary approach, not an ad-hoc combination of approaches advocated from supervisors in different disciplines. Having a programme coordinator who oversees all students in a given interdisciplinary domain, facilitates interdisciplinary research meetings for students and so can help to ensure that these students are indeed working within an interdisciplinary framework and, at the same time, provide them with a disciplinary home rather than risking them feeling peripheral to whichever department in which they are hosted. This oversight is especially important in countries such as New Zealand where doctoral candidates only complete a research thesis and do not undertake coursework as part of the doctoral degree.

Creating barriers

An alternative to having individuals straddle departments is to create a separate identity for interdisciplinary programmes such that they are not beholden to host departments and disciplines for support—structures that enable them to access facilities (e.g., funding, equipment, student scholarships) in their own right rather than via host departments. This can be achieved through establishing interdisciplinary departments—so instead of biochemistry spanning the departments of biology and chemistry there is a department of biochemistry. Or to prevent a proliferation of departments, an alternative would be to create a school in which there are domains of chemistry (and subdisciplines within), biology and biochemistry, each with equal status. Interdisciplinary research institutes can be created in which all members, research projects and grants are by necessity interdisciplinary so there is no between-discipline competition. Ironically then the best way to ensure the sustainability of interdisciplinary programmes is to embed such interdisciplinarity within the traditional discipline-based structure—have interdisciplinary programmes become disciplines!

There is a risk in such an approach, however, that interdisciplinary studies become detached from their constituent domains. Such barriers may also sustain existing interdisciplinary programmes but might they at the same time inhibit the emergence of new interdisciplinarity?

Developing and sustaining interdisciplinary programmes is not easy. It requires both structural and attitudinal shifts within institutions. The contribution of multi- and inter-disciplinary approaches to solving major problems in society indicate that efforts to ensure their continued development must be made and cannot be sacrificed to institutional inertia.

Creating a Governance Model to Foster and Sustain Interdisciplinary Graduate Programs

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Introduction

Eastern Illinois University strives to meet the expectations for best practices outlined by the Council of Graduate Schools by working to create a culture of excellence in graduate education and ensuring that governance structures foster and sustain that excellence. Following multiple efforts to create Eastern's first professional science master's degrees, the Graduate School determined that Eastern's existing governance structures were insufficient to support interdisciplinary degree opportunities. To address that issue, the Graduate School launched a new governance board, the Interdisciplinary Graduate Studies Board. This new governance model was essential to creating a pathway for individual departments to collaborate and develop interdisciplinary graduate degrees.

Historic Governance and Approval Processes

Historically, the University managed its new degree approval processes using a traditional model requiring that an academic department create and approve a new degree program followed by approvals of the college curriculum committee and the Council on Graduate Studies. In 2009, a group of faculty members began the process of developing a new interdisciplinary professional science master's degree, the Master of Science in Geographic Information Sciences. This program required courses from seven participating departments: geology/geography, biological sciences, mathematics, economics, political science, technology, and business administration. Because the governance structures favored creation of degrees within individual departmental disciplines, these programs had no standard processes for resolving typical and atypical issues that always emerge with the development of a new degree. The challenges included finding a process for gaining individual department, chair and dean support to participate in the degree, creating a process for engaging faculty to convene and advance discussions regarding the curriculum, and implementing an overall structure to approve the final curriculum. The lack of a governance structure prolonged the development of the degree and created frustration for the program leaders. As an initial step toward seeking a long term solution, a Professional Science Master's Board was developed and launched in 2011. The new PSM Board immediately provided some of the structure required for the resolution of problems and a nurturing environment to foster rigor and excellence. There were several key features of the original PSM Board that significantly assisted the new program coordinators. These included access to the deans and chairs of the participating departments who provide access to and commitment to the resources essential to the health of the program. Another key factor included regularly scheduled meetings to foster engagement and exchange of information with participating departments and colleges.

Launching a New Governance Model: The Interdisciplinary Graduate Studies Board

After analyzing the value of the PSM Board, the Graduate School proposed to the Provost that an Interdisciplinary Graduate Studies Board be created. The mission of the IGS Board was to develop a scaffold of support structures that would nurture existing interdisciplinary graduate programs and provide guidance and incentives for the development of new interdisciplinary programs. The Graduate School's IGS Board was launched in 2012 and included representatives from two existing interdisciplinary programs: the MS in Geographic Information Sciences and the MA in Gerontology. The Board also included representatives from five emerging interdisciplinary programs: the MS in Sustainable Energy, the MS in Health Promotion and Leadership, the MA in Arts Administration, the MS in Cybersecurity, and the MS in Biochemistry/Biotechnology.

During its earliest meetings the IGS Board outlined its purposes as follows:

- **Mission:** The mission of the Interdisciplinary Graduate Programs Board is to receive updates from the program leaders on approved and developing interdisciplinary graduate programs, to identify and resolve issues, and to provide guidance to developing programs.
- **Approvals:** All interdisciplinary graduate programs will develop an advisory board composed of a representative from each of the participating programs. The faculty members serving on the board are responsible for developing curriculum, courses, student assessments and related curricular matters. The approvals will move from individual department approval of courses, to approval of the degree program and requirements by the Interdisciplinary Advisory Board. Once the departments and Board have approved the curriculum, the approvals advance to the academic college that serves as the “home” of the program, to the Council on Graduate Studies, and finally on to the State Board of Education for final approval.
- **Board Members:** The IGS Board includes at least one representative from each current or progressing interdisciplinary program who would typically serve as the graduate coordinator, the department chair from the department that provides an academic home for the program, the college deans, and the Dean of the Graduate School who will convene the meetings, set the agendas, and implement the policies. Each new interdisciplinary program that wishes to advance will begin by adding a program coordinator and a department chair to the IGS Board.

Key factors that have helped interdisciplinary study grow with the new Governance Board Model:

- **Academic Home:** Every interdisciplinary program must first establish an “academic home” that includes an existing department that agrees to serve as the caretaker and supporter for the degree program. The academic home ensures that standard requirements for all degree programs are managed by the program coordinator and host department chair. Every program also has an academic college home so that it receives the support of resources and needs.

- Degree Advisory Board: Each interdisciplinary program has a Degree Advisory Board that typically is composed of a representative from each of the disciplines participating. These Boards establish their own missions, bylaws, and agendas; however, they make their agendas, minutes, and related decision making documents available to the IGS Board so there is a continuous flow of information from the degree program back to the chairs and deans. The degree advisory boards meet according to the needs of their degree programs.
- Fiscal Agents on IGS Board: Department chairs of the departments that host interdisciplinary programs and the college deans of these departments serve on the IGS Board and are available to resolve standard fiscal concerns. These include replacing faculty who may be unavailable due to sabbaticals or resignations, securing resources for recruitment, organizing processes such as accreditation or securing the PSM designation, and ensuring operational needs such as supplies and travel, essential to sustain the program. The IGS Board hosts meetings for all participants twice each year; the second Thursday of September and February. These meetings always include a review of resource needs and updates on programs and approvals.

The positive outcomes of this approach have been to achieve approval and launch the MS in Sustainable Energy and MS in Health Promotions/Leadership in less than one year. We also made more rapid progress with the decision to delay further discussion of the MA in Arts Administration until the participating programs were able to provide the support needed to advance the degree. We also have two additional degrees under consideration; the MS in Cybersecurity and MS in Biochemistry/Biotechnology. While not all problems have been resolved, the Governance Board Model has worked well for Eastern.

Building Strong Interdisciplinary Graduate Programs in Xiamen University

Tao Tao
Executive Dean, Graduate School
Xiamen University (China)

Xiamen University is a comprehensive university which was founded by Mr. Tan Kah Kee in 1921. It is now one of a small number of remarkable institutions in China designated as national key universities and offering 276 master's programs and 187 doctoral programs. The university now has a total enrolment of over 40,000 full-time students on campus, including 20,000 undergraduates, 17,000 master's degree students, and about 3,000 doctoral students. To improve its education and research, Xiamen University has been paying close attention to building interdisciplinary programs. There are following key issues in building advanced interdisciplinary graduate programs in the university.

Strategies

The establishment of interdisciplinary graduate programs was mainly based on existing key disciplines such as economics, law, chemistry, biology and marine sciences. The university strongly supports the forefront research which could be a promising start of a new discipline. Establish interdisciplinary institutes which provide a favorable education and research environment in the university.

Measures

1. Invest more money into interdisciplinary programs;
2. Design a brand new core curriculum for each interdisciplinary graduate program;
3. Set up new assessment standards for advisors who supervise graduate students in the interdisciplinary graduate programs;
4. Assessment of interdisciplinary graduate programs is conducted regularly;
5. Establish interdisciplinary institutes: there are about ten interdisciplinary institutes in the university;
6. Set up multiple awards and grants in the university to promote interdisciplinary education and research.

All the measures will be presented and discussed in detail at the summit.

Engaging Academic Staff in the Supervision of Interdisciplinary Doctoral Degree Programmes in the UK: Turning Round the Super Tanker of Monodisciplinarity

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Some academic staff place themselves firmly in interdisciplinary spaces from the outset of their career, continuing with this commitment throughout their academic careers, challenging the status quo and dominant paradigms in their institutions and mentoring colleagues and PhD students as they go. Many more develop interdisciplinarity through the established disciplines, developing not only the knowledge and skills to do so but inheriting the established values and cultural norms of their mono-discipline. This begins with the socialisation process of their training—their doctoral degree.

There is a degree of safety for academic staff in terms of personal academic progression in supervising disciplinary-based doctoral degrees, mitigating any associated risks to the successful supervision and examination of a PhD student in a competitive environment. This has a self-reinforcing influence running contrary to interdisciplinarity. However, despite the risks and challenges associated with interdisciplinarity it can be argued that doctoral degree programs are exactly where the development of interdisciplinary research has the best opportunities. The beginning of the socialisation process begins in the doctoral cohort but requires the engagement and commitment of supervisors.

There are many challenges within the UK higher education context to fostering academic engagement with interdisciplinary supervision, many of which are historical and related to established norms for assessing research progress. Increasingly top-down drivers from the UK Research Councils and funding bodies like to see institutional strategies which address these challenges. This is evidenced through the recent Research-Council-funded development of Doctoral Training Centres (DTCs) and even more recently in Doctoral Training Partnerships (DTPs).

The competitive system for assessing the quality of research within Higher Education Institutions in the UK known previously as the Research Assessment Exercise (RAE) and now the Research Excellence Framework (REF) informs the selective allocation of the funding bodies' grants for research. This is accepted across the UK as primarily a disciplinary-focused exercise and concerns have been repeatedly expressed by academics across the sector that this assessment was a disincentive to interdisciplinary research. In the RAE/REF submission system there is no clear place to submit interdisciplinary outputs and furthermore assessment panel members are selected because of their monodisciplinary expertise and often do not possess the interdisciplinary expertise to know how to assess it appropriately. The Higher Education Funding Council

¹ This paper was co-authored by Mick Fuller, Head of Graduate School, Plymouth University and Chair, UK Council for Graduate Education (UKCGE).

for England (HEFCE) attempted to address these concerns explicitly within the guidance to institutions for submissions to the Research Excellence Framework (2014) but it takes a long time to turn around a super-tanker of monodisciplinary research.

Within research intensive UK universities, the importance of the outcomes of the national assessment framework for the personal development of individual members of academic staff cannot be emphasised enough and despite attempts to address concerns about how and where to measure interdisciplinary research there is a persistent understanding that it is easier and safer to publish within, and submit to, single units of assessment. For doctoral education in the UK, this means that it is more likely that supervisors, subject to these competitive pressures, will encourage a disciplinary-focused PhD that will fit established spaces and pass on the norms of the disciplinary-focused education that they received themselves, thus reinforcing monodisciplinary. There remains a personal career risk for academics to enter interdisciplinary research spaces and structurally and procedurally there are barriers. A cursory review of published criteria for promotion for academic staff on the websites of UK Higher Education Institutions also reveals little or no reference to developing interdisciplinary research as an incentive for promotion.

Unlike the North American model, the British doctorate has traditionally been based on the assessment of a single thesis after a period of “apprenticeship” with little or no formal courses and no accumulation of credit. This approach has been significantly altered in recent years so that the UK is moving increasingly towards a more structured training environment with considerable reflection on how best to support the development of researchers and the next generation of academic staff able to compete in a globalised economy, supporting and furthering UK PLC. The focus of the doctorate as being a socialisation process for future academic staff within the disciplines has been eroded somewhat with the increased focus on the agenda for generic/transferable skills development that has grown since 2003 in response to the Robert’s Review.

The growth of graduate schools since 1994 in the UK has provided an organisational space for the changes to the British Doctorate and now in 2014 there will be new supervisors who have experienced the altered UK doctorate. This has taken considerable time and has required cultural change that is still ongoing. Research students are now more likely than ever before to engage with students from other disciplines within the new UK graduate school training space fostering the potential for establishing cross-disciplinary, multi-disciplinary and interdisciplinary conversations and ideas. As supervisors increasingly acknowledge that doctoral students need to be prepared for a career outside academia where disciplinary divides are not as relevant, the appetite to foster interdisciplinary activities increases.

Research students in the UK are now supervised typically by a team of at least two supervisors with opportunities for cross-disciplinary supervision and intellectual diversity within this model. However, the formation of supervisory teams with staff from different disciplinary cultures requires an additional level of personal commitment both from the academics concerned and their management teams. The examination of research students within the UK provides a significant additional challenge in accessing examiners with interdisciplinary expertise. However, as with supervision, once an academic is recognised to have interdisciplinary expertise then they are more likely to be invited to supervise and examine interdisciplinary research students.

The emergence of doctoral training centres (DTCs) funded by the Research Councils in the UK were intended as a mechanism for increasing capacity in interdisciplinary research activities in areas that were difficult to locate within a single discipline structure. The recent emergence of Doctoral Training Partnerships funded by the UK Research Councils provide significant encouragement to academics to engage more collaboratively with partners in the supervision of PhD students and engage in interdisciplinary programmes in collaboration with other universities. Doctoral Training Partnerships are now the main mechanism for the distribution of the UK Research Councils' postgraduate funding with an emphasis on encouraging interconnectivity across disciplines and across universities through the training of doctoral researchers. Engagement with the supervision of Research-Council-funded students carries prestige and will rather force academics to engage in doctoral degree programmes and training that foster interdisciplinarity.

Success in further encouraging academic staff to engage with interdisciplinary degree programmes within the UK will require further investment from individual institutions and the encouragement of bottom-up approaches linking personal success and progression to this agenda. This will require further cultural change (which takes time), explicit links to funding and research quality assessments and the continued development of doctoral training approaches equipped to mitigate the risks to supervisors and students.

European Doctoral Education: Programme Assessment within the Framework of Quality Assurance

Melita Kovacevic
CDE Steering Committee Chair
European University Association

In the last decade European doctoral education has been going through significant changes, both in terms of the structure and content. We have recognized the whole process as a “quiet revolution” in which universities put a lot of efforts in reshaping the traditional system of doctoral education. A majority of European universities identified doctoral education as a core university activity that is crucial for training researchers as well as for institutional research status. Doctoral education gained a strategic role for the majority of European universities, emphasizing both international collaboration and industry-university partnerships. This kind of importance that has been attributed to doctoral education required rethinking both on the structural institutional level and in terms of the content and form of the doctoral programme *per se*. Educating and developing researchers has been recognised as central to the development of knowledge societies.

Presently, we have about 600,000 doctoral candidates and are ever increasing the number of graduates per year. At the same time our focus is on nurturing quality in doctoral education in order to increase doctorate holders’ accountability and to make them more attractive for employers.

Traditionally, many universities did not have structured doctoral programmes, the completion time was longer, and universities’ interest in completion rate was different. For many doctoral candidates the whole process of doctoral education has been based on a relation between the doctoral candidate and the supervisor. Universities were not much involved in what was happening with the doctorate holder after the graduation. There was little communication, if any, with the third party. Accordingly, all the efforts had been put on research itself and personal management of the relationship between the doctoral candidate and his/her supervisor.

With a shift in a doctoral education, there is a noticeable effort in professionalizing the process. Nowadays, doctoral education is performed predominantly through doctoral schools. Universities and doctoral schools are paying much more attention to quality enhancement. These way doctoral programmes gained a different role. Their relevance has been put on different coordinates. There are significant differences between quality assurance for doctoral education and the first two cycles, as we call them according to the Bologna Process (bachelor’s and master’s).

The European quality assurance system has been based on three main components—accountability, quality enhancement, and quality culture—which embrace everyone involved: teaching staff, doctoral candidates and management. This has also been a requirement

reflected in doctoral programmes. Universities needed to establish a system which will provide professionalised support both to doctoral candidates and research staff as well as to develop the system which will be able to monitor and further develop doctoral education.

Today we know that our doctoral programmes and doctoral education, in general, has been evaluated by various external and internal evaluations. There is ongoing monitoring of the system. We are aware of different models of evaluations and assessments, sometimes being focused more on institutional global level, sometimes more on individual programmes. There is a whole array of numerous different approaches going from the individual programme accreditation process to institutional audits, assessments within the national qualification frameworks and specific learning outcomes, internal regular and/or periodic evaluations and continuous monitoring of doctoral candidates' progress. A relevant question is what is specific about doctoral education and how to use the key performance indicators when assessing a doctoral programme.

Nevertheless, our main concern is good quality supervision. We have many good practices that show how to use supervision for enhancing the quality. A doctoral programme itself requires flexibility and possibility to be adjusted to the individual needs of a young researcher. It should also be responsive to different needs of doctoral candidates coming from different cultural and educational backgrounds. We perceive this global, international component to be extremely relevant for doctoral programmes and doctoral education. A good doctoral programme should also be capable of career tracking and developing services for career development. In this context, special emphasis has been put on transferable skills training.

Doctoral education is still facing many challenges. Although all three educational cycles share the same purposes for quality assurance, we need to be aware that there are different processes. When assessing doctoral programmes, one should never forget that the main feature of doctoral education is training through original research. Presently, there are many and regular evaluations of doctoral education and assessments of doctoral programmes across European universities. The fact is that doctoral education differs qualitatively from the first two cycles—that is research—and due to that fact, specific, customized forms of assessment and evaluation need to be administered.

4: Innovations in Interdisciplinary Learning

Innovations in Interdisciplinary Learning: Informal or Extracurricular Opportunities

Nancy H. Marcus
Dean of the Graduate School
Florida State University (United States)

In the last decade more and more attention has been given to interdisciplinarity. A myriad of books, articles, conferences, and workshops have been devoted to this topic. Graduate educators are encouraged to emphasize interdisciplinarity in the training of graduate students so that the next generation of scholars is prepared to tackle the complex issues facing society today and in the future. It is generally acknowledged that solving the big issues confronting society such as climate change, water shortages, extreme events, and health requires input and understanding from many perspectives. At issue is agreement on—“What is the best way to prepare people to tackle these problems?” Actually there is not probably a single best way. For institutions of higher learning it is very dependent on history and organization. Colleges and universities have been a big part of the discussion because the faculty are often engaged in the very research that is necessary to solve these problems. To promote the interaction of faculty affiliated with disciplinary-oriented departments, universities typically create research centers or institutes to physically or virtually house researchers who are tackling a common problem, but from different angles. This approach can be effective and research centers can provide the foundation for establishing interdisciplinary graduate degrees. However, as we all know there are numerous hurdles to overcome in establishing an interdisciplinary graduate degree. These include concern for the shifting of financial resources, competition with disciplinary degrees, and simply the “cultures” of different disciplines. Florida State University offers several interdisciplinary degrees at the graduate level. Some have existed for decades, others are fairly new. The organization, administration, and financing of these programs do not reflect a single model. Some just include departments from a single college, but others cross colleges, though administrative authority is accorded to a single academic dean. The degree established most recently is Materials, Science, and Engineering (MSE). MSE involves faculty from the College of Arts and Sciences and the College of Engineering. The program is housed under the Graduate School. The Program Director is appointed by the Dean of the Graduate School. There are no tenure lines in the program; all faculty are affiliates from their departments. It remains to be seen if this model can be successful at FSU.

I provided this description of degree programs at Florida State University as context for the remainder of my remarks. Creating successful and meaningful interdisciplinary degree programs is challenging. In my opinion it should not be the first step in promoting interdisciplinarity on a campus. I think that there are numerous other informal programs and activities that one can offer within the framework of academic institutions that promote interdisciplinary engagement. In fact, I believe that the development of interdisciplinary initiatives at Florida State University, especially degree programs, has been hampered by the very decentralized structure of the institution. As Graduate Dean I am very cognizant of this culture and am careful to focus on programs and activities that can complement and enhance the academic experience students

gain in their departmentally-based degree programs. Three areas where I think The Graduate School can make a difference are promoting: 1) interdisciplinary engagement and reflection; 2) international experiences; and 3) professional development. The remainder of my presentation will focus on approaches we have taken to promote interdisciplinary engagement and reflection at the graduate level, through informal mechanisms, which are the focus of this session. In the last several years The FSU Graduate School has established three programs to foster the interdisciplinary engagement of graduate students. These are: 1) The Fellows Society; 2) a competitive awards program to support symposia or conferences proposed by graduate students that are interdisciplinary in nature; and 3) support to foster students being able to take coursework outside their home unit, especially involving courses outside their college.

The Fellows Society

The Fellows Society brings together our outstanding graduate students who hold competitive university-wide fellowships for the purpose of interdisciplinary learning. Graduate students whose merits have been recognized through national fellowship programs, such as the Gates Millennium Scholars, NSF Graduate Research Fellowship Program, Charlotte W. Newcombe Fellowship, Woodrow Wilson Fellows, and other qualifying fellowship programs are also invited to become members.

Each year, members of the Fellows Society organize an interdisciplinary symposium that addresses a complex problem of broad humanistic significance. The 2014 Fellows Forum was entitled “Keeping an Eye on the Digital Divide.” It included speakers from a broad range of disciplines including Urban and Regional Planning, Instructional Systems, and Psychology.

Interdisciplinary Symposia and Conferences

In an effort to encourage graduate students to think broadly and across disciplines, The Graduate School offers support for symposia/conferences/meetings that are organized and hosted by FSU graduate students. The funds can be used to defray travel expenses of a keynote speaker, food, printing, etc. There is an annual solicitation for proposals. Priority is given to proposals whose organizing group includes participants (graduate students, postdocs) from more than one academic unit. The greater the diversity of disciplines the better, as the goal is to promote interdisciplinary dialogue and appreciation for a wide array of perspectives.

Interdisciplinary Course Waivers

College budget allocations at FSU are driven by student enrollment so some colleges discourage or do not provide tuition waivers for a course outside the college. The Graduate School established the Interdisciplinary Course Waiver program which provides graduate students the opportunity to request a tuition waiver through the Graduate School allocation for one course outside of their home College that will contribute to their degree progress.

Innovations in Interdisciplinary Learning: Informal and Extracurricular Opportunities

Marie Audette

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Université Laval (Canada)**

Background

The importance of using interdisciplinary approaches has grown over the past decade. Interdisciplinary thinking is rapidly becoming an integral feature of research, as a result of the need to solve complex societal problems and the desire to explore problems and questions that are not confined to a single discipline.¹ Interdisciplinary research and learning is associated with creativity, progress, and innovation,² and is considered as an essential key to a knowledge economy.

There are a variety of opportunities for students to further their interdisciplinary knowledge and skills and build a community of young interdisciplinary scientists, and to learn about and share issues regarding interdisciplinary research and learning. Besides formal curricular training, students and their supervisors should be encouraged to share experiences, issues, problems and solutions/good practices regarding interdisciplinary collaboration.³

Université Laval (ULaval), the first Francophone university in North America, situated in Quebec City, is a comprehensive university of about 48,000 students, including approximately 10,000 graduate students. It offers 263 graduate programs including 160 master's and PhD programs. Among these, about 60 comprise an important interdisciplinary component. Furthermore, the Faculty of Graduate and Postdoctoral Studies offers *ad hoc* interdisciplinary master's and doctorate programs. At ULaval, Institutes and some Research Centers are responsible for developing initiatives of added value, outside the regular curricula, to form young researchers and practitioners with high interdisciplinary skills. Below are four examples of ongoing extracurricular training activities developed at ULaval.

Integrated Training in Biophotonics: an added value to an interdisciplinary program

ULaval offers master's and doctoral degrees in Biophotonics, where highly qualified students are trained in chemistry, biology, neuroscience, and optics-photonics and pursue research activities under the co-supervision (compulsory) of directors from different disciplines, and undergo continuous assessment of a multidisciplinary advisory committee who together bring a diverse perspective to research problems. The program-associated faculty members, through a federal training grant,⁴ have designed a series of extracurricular activities to better support the interdisciplinary learning of their students. A summer school entitled *Frontiers in Neurophotonics* is an extracurricular activity, designed for graduate students registered in the

¹ National Academy of Sciences (2004) Facilitating Interdisciplinary Research. ISBN: 0-309-54727-X, 332 pages

² Buanes, A. & Jentoft, S. (2009) Building bridges : Institutional perspectives on interdisciplinarity. *Futures*, 41 : 446-454.

³ Lyall, C. & Meagher, L.R. (2012) A Masterclass in interdisciplinarity : Research into practice in training the next generation of interdisciplinary researchers. *Futures*, 44 : 608-617

⁴ http://www.nserc-crsng.gc.ca/Professors-Professeurs/Grants-Subs/CREATE-FONCER_eng.asp

interdisciplinary master's or doctoral programs in Biophotonics, but is also open to students and postdoctoral fellows from other disciplinary fields such as chemistry, physics, cell and molecular biology and neurosciences, from ULaval or universities in Canada and abroad. The summer school gives them the opportunity to meet with international experts from different disciplines to discuss the latest advances in optical imaging of living cells during the morning seminars. "Hands on" training on different techniques, as well as informal discussions and networking activities are offered in the afternoons and evenings. Students enrolled in the Biophotonics program can broaden their perspective through internships in industrial settings, in Canada and abroad. Among other initiatives launched to support interdisciplinary learning is the Annual Symposium in Neurophotonics, entirely organized by the students and offered in rotation with the University of Bordeaux (France). Students exposed to the enrichment program are better prepared for their future career and some success stories are reported.

Training program in Functional Foods and Technology: added value to disciplinary training

The Institute of Nutrition and Functional Foods (INAF) offers in collaboration with the University of Winnipeg, a training program that comprises a summer school as well. In this particular case, students and fellows come from disciplinary fields such as chemistry, chemical engineering, nutrition, microbiology and medicine, but are invited to discuss and work together on a practical problem—How to develop a functional food from milk, for instance. During this problem-solving oriented activity, they can learn Canadian rules and regulations related to food production, interact with specialists of large-scale industrial production, and be initiated in the principles of marketing ethics. Students have the opportunity to further their experience through internships in government or private laboratories that are regular partners of the program. While keeping their disciplinary identity, the trainees learn to work within an interdisciplinary team to solve a practical problem.

Sustainable Development: interdisciplinary conversation with the civil society

Sustainable development is a key element of ULaval's development plan, in its training and research mandate, and in its good management practices. ULaval hosts the Institute on Environment, Development and Society (IEDS). The IEDS is highly interdisciplinary, its members coming from many disciplines: geography, law, economics, social sciences, biology, forestry, engineering, and education, among others. It offers a series of activities including a Fall University on Sustainability. Besides regular conferences, the Fall University holds a town hall meeting where students, experts, and people from the community discuss issues of concern in sustainable development, giving the students the opportunity to develop their interdisciplinary skills but also to learn and to translate their knowledge about a real world problem in civil society.

International Studies: interdisciplinary conversation with the world

The *Institut Québécois des Hautes Études Internationales* (IQHEI) offers master's (mainly course-based with internships) and doctoral programs in international studies, combining law, politics and economics. IQHEI has integrated social networking and social media in its summer schools in order to build and strengthen the interdisciplinary community, and to promote knowledge translation to the civil society. Extracurricular design-based learning that is student-

initiated and student-directed supports innovation, motivation, learning and achievement.⁵ SPECQUE (*Simulation du Parlement Européen Canada-Québec-Europe*) is an international French-speaking model of the European Parliament (EP). Founded in 1998 by students from the IQHEI, it has become a reference model on both sides of the Atlantic. It gives its participants from all over Canada and Europe an insight into the functioning of the EP. The debates allow for a direct exchange of knowledge in international and interdisciplinary perspectives, and contribute to open-mindedness. Students from the IQHEI have also launched (in 2006) the journal *Regard Critique* that publishes articles submitted by graduate students from all over the French-speaking world. It promotes opinion diversity, neutrality and integrity in an interdisciplinary perspective, and raises awareness among the general public about international issues.

Conclusion

Extracurricular activities designed to support formal interdisciplinary training enrich and broaden the horizon of knowledge, ensure a framework of practicing and cultivating some skills and often in a more casual environment.⁶

⁵ Gerber, E., Olson, J.M. & Komarek, R.D.L. (2012) Extracurricular Design-Based Learning : Preparing Students for Careers in Innovation. *International Journal of Engineering Education*, 28 (2) : 317-324.

⁶ Chisiu, C.M. (2013) Extracurricular activities, an alternative for interdisciplinary learning. *Postmodern openings*, 4 (4), 67-79.

Encouraging Research Students to Explore and Develop Cross-disciplinary Collaborations

Roger Horn
Dean of Research Training
Deakin University (Australia)

There is no doubt that interdisciplinary research can produce wonderful results, often breakthroughs, by finding fertile ground in the area between two current disciplines, and/or by capitalising on some cross-pollination of ideas to produce a real breakthrough. Most experienced researchers would have witnessed the outcomes of interdisciplinary research and would appreciate the value of encouraging it. However, the potential benefits might not be apparent to research trainees. If we want to encourage interdisciplinary research and the exciting possibilities that it brings, we need to train our research students to understand the benefits and to have some strategies for pursuing interdisciplinary topics. We should also provide opportunities and incentives for pursuing those strategies.

The best interdisciplinary research is, I believe, done through collaboration. It would take an exceptionally gifted person to acquire sufficient expertise in more than one discipline to become a strong interdisciplinary researcher on their own. Training a person in multiple disciplines is more likely to produce breadth than depth; the phrase “jack of all trades and master of none” comes to mind. But drawing together different people with real expertise in different fields to work on one problem can produce wonderful synergies, and the vast majority of research students would be better advised to seek collaborations if they want to conduct inter- or cross-disciplinary research that is effective and at the cutting edge. Fruitful collaborations might succeed by identifying new research problems lying between two fields (interdisciplinary research), or by bringing knowledge from one field to another (cross-disciplinary research). A person from outside a particular discipline can bring an entirely new way of thinking or methodology to an established field and produce valuable new insights, while their collaborator who is trained in the established field will understand the validity or otherwise of the novel methodology. In the remainder of this paper I will consciously use the term “cross-disciplinary” research, implying collaboration and a *combination* of two disciplines, rather than “inter-disciplinary” which implies work in an area *between* two disciplines.

Following this reasoning, what we need to do is encourage collaborations between researchers. This means, first, developing positive attitudes in people so that they appreciate the benefits of collaborating and are open to ideas from outside the discipline they are trained in; second, creating opportunities for researchers to meet each other; and third, providing strategies, encouragement and incentives for people to develop real collaborations. One simple and effective incentive would be to offer seed funding for interesting cross-disciplinary grant proposals. That might seem “formal” and thus outside the scope of this panel, but we will return to it later as a useful adjunct to some less formal approaches.

Collaboration by definition requires the involvement of more than one person, and informal or

social opportunities can provide the opportunity to meet other researchers. Various possibilities exist for arranging meetings between researchers from different areas. For example, there could be social events such as parties, barbeques, social sports, or cultural tours. However, we need to do more than simply arrange meetings; we need to introduce people *and* their research topics. This is best done in a semi-formal arrangement, a forum in which people from diverse backgrounds present their research to each other. There may need to be encouragement, incentivisation, or even compulsion to attend—our experience is that all too often students are not enthusiastic about listening to research topics that are not closely related to their own. To a large extent this is, I believe, because new or inexperienced researchers have not learnt to appreciate the unexpected benefits—the random ideas, cross-fertilisation and synergies—that can come from listening to research talks from other areas. These benefits need to be explained to research students, perhaps illustrated by some real examples.

One possible way to bring research trainees together is a multi-disciplinary, faculty- or even university-wide, student conference. Students would present short conference-style talks on their research work. Clearly these need to be pitched at a level appropriate for a diverse audience. The sessions would include time for questions, as usual at a conference.

Another possible forum that has become popular in Australia and New Zealand is a three-minute thesis competition. As developed by the University of Queensland, the 3MT¹ encourages research students to present a talk about their research topic to a general audience, with no more than one static PowerPoint (or similar) slide and no other props or special effects. In addition to providing training in the skill of making “the elevator pitch,” these events have proven highly informative and entertaining for the audience.

Enabling opportunities for students to hear about topics in other disciplines is only half the battle, however. The other half is to encourage them to think about possibilities for cross-disciplinary research. Could they incorporate other ideas into their own research, or contribute their own ideas, knowledge and research methods to other areas? Taking that extra step may require encouragement in the form of incentives or obligatory exercises.

We could draw a parallel with matchmaking. Only a small fraction of matches are going to produce magic, but to maximise the chances of finding that magical one we should maximise the number of contacts between researchers. To push the matchmaking analogy further, arranged matches or partnerships imposed from above are less likely to succeed than those where the participants find a natural chemistry by themselves. And still further, we might think of ways to encourage “dating” in the hope that at least a fraction of those dates will result in enduring and productive partnerships.

One possibility would be to organise a “speed dating” event in which research students are cycled through one-on-one conversations with others, each lasting a few minutes. Each person briefly describes their own research topic and research methods and the other can ask questions about it. If there is mutual interest, contact details can be exchanged and arrangements made for a longer follow-up conversation in which potential collaborations can be explored. If the pair finds no interest in each other’s work, then no more than a few minutes has been lost. Whether or

¹ See <http://www.uq.edu.au/grad-school/three-minute-thesis>

not good matches are found, however, the greatest benefit lies in *training* people to listen to and think about research ideas and methods from other fields.

All of these suggestions (whether they include a speed-dating event or not) may need to be driven by incentives, such as making seed funding available for the best cross-disciplinary project proposals, or by less formal incentives such as challenging students to produce a proposal. Alternatively, there could be coercion in the form of making participation in these events a mandatory requirement of a research training program.

Mentoring of Graduate Students in Interdisciplinary Programs at Purdue University

Mark J. T. Smith
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Purdue University (United States)

Mentoring interdisciplinary students is a university obligation deserving of our best effort. Empowering students to tackle problems that span multiple disciplines is becoming more and more important as the complexities of society expand. Whereas many of the important advances in the past were made by single individuals in traditional fields, today we are seeing research teams leading innovation and discovery in a space where broad prerequisite skill sets are essential. It comes as no surprise that interest in interdisciplinary research at Purdue University (and elsewhere) is increasing. In fact, within the Graduate School's Office of Interdisciplinary Graduate Programs (OIGP), enrollment has increased by 74 percent over the last seven years. In conjunction with this growth comes the responsibility to assure students in these programs receive proper academic guidance, meaningful career counselling, and high quality research advising.

Universities are often challenged in meeting this responsibility because interdisciplinary programs typically are not structured with direct faculty lines, departmental teaching assistantships to support students, and a sufficient number of faculty advisors equipped to provide multidisciplinary career guidance. While quality mentoring is critical for all students, it is particularly important for interdisciplinary students because of the often unique environment in which these students are situated. In contrast to traditional disciplinary programs where degree titles are well understood externally by employers in industry, government, and academic sectors, interdisciplinary degree titles are often not well understood in terms of what specific skills graduates of these programs possess. So, some specific coaching and counselling on how to sell one's self can be very helpful to students when applying and interviewing for job positions.

Students in interdisciplinary programs can find their access to resources limited, relative to other students. We see this typically when a grant expires and a student needs a teaching assistantship or departmental research assistantship to bridge the gap between grants. Rarely do we see traditional departments step in to assist interdisciplinary students with support because these students are perceived as being outside of the departmental program. Furthermore, interdisciplinary students can feel at times disconnected from the university grid in the sense that many of the communications channels to graduate students that provide important information about deadlines, professional development opportunities, special campus programs, and so on are overseen by departments who may not include interdisciplinary students in their communications.

Interdisciplinary programs at Purdue can differ significantly in terms of their operating models, which can make a one-size-fits-all approach impracticable. Nonetheless, we prefer to address these issues or at least oversee these programs centrally. In this way, we help assure that interdisciplinary students are consistently receiving the mentoring and support they need.

At Purdue University, sixteen interdisciplinary degrees are housed in the Office of Interdisciplinary Graduate Programs (OIGP). These programs offer master's and PhD degrees, and can have different administrative structures. OIGP programs include many STEM-oriented degrees such as Biomedical Sciences, Computational Life Sciences, and Information Security, as well as programs with a liberal arts flavor, such as American Studies, Comparative Literature, and Women's Studies. In addition, a new OIGP interdisciplinary PhD program was just approved that is completely customizable. Initially motivated by the interest in providing faculty members working in Discovery Park centers on campus with a convenient way to engage talented students in PhD research, the interdisciplinary PhD program allows students to identify an advisor and together select a thesis committee and define a plan of study. This flexibility has many obvious benefits, particularly for ambitious students seeking to explore solutions to grand challenge problems. As mentioned above, there are mentoring challenges associated with running these programs, which we attempt to manage. We have learned a number of lessons along the way, which are shared in the remainder of this article.

The administrative model that has generally worked best on the Purdue campus is the one used in the *Purdue University Life Sciences Program* (PULSe). Students in PULSe are admitted directly into the program, which is organized around ten training groups (TG's), involving more than 200 faculty members from 30 different departments. Each TG has an Executive and Curriculum Committee to provide oversight and one-on-one advising to the students. PULSe is structured to provide a common set of basics relevant to each Training Group while providing flexibility for students to appropriately customize their programs in accordance with their individual interests. Recognizing the importance of exposure in making good decisions, students are directed to explore several training areas and are required to do laboratory rotations before selecting their PhD research topic. After the student has chosen an area, an advisor is identified, along with a thesis advisory committee. An important feature of PULSe is that the department of the thesis advisor becomes the official department home of the student. This enables the student to have a convenient connection to a department (and department resources) without the additional departmental constraints and requirements that may not be appropriate for interdisciplinary research.

The new Interdisciplinary PhD program has even more flexibility and includes the same important feature that the home department of the thesis advisor serves as the departmental home for the student. The transcripts for students who participate in these programs clearly indicate the interdisciplinary program affiliation in addition to the department name.

Some Lessons Learned

There is value in having academic flexibility within an interdisciplinary program—flexibility that allows the thesis advisor and committee some latitude to tailor the plan of study to the interests of the student. This typically involves getting departments to agree upfront to entrust participating faculty mentors with this responsibility.

Mentors serve the students well by teaching them how to market themselves externally to different types of audiences. This involves helping the students learn and/or discover what specific qualities and skills a particular employer may be looking for.

It is valuable to have mentors expose students to discipline-specific as well as interdisciplinary outlets for presentation and publishing. More often than not, these communities are different and have dissimilar cultures. Interdisciplinary students should be navigating both of these communities and associating with the appropriate professional societies right from the start. Mentors should view themselves as career guides.

Students benefit greatly when mentors help them seek out and secure external funding. There are funding opportunities for students who wish to engage in “translational” research, but sometimes these opportunities are not apparent to the students. Good mentoring and advising is key.

Engaging interdisciplinary program alumni/ae as role models and mentors can provide valuable career insight for enrolled students. A simple way to do this is to invite alums to campus to give seminars and for panel discussions. The alums often have good stories to share and can speak about opportunities. Furthermore, they can be a resource for internships and employment connections.

Another practice we’ve found to be effective is providing recognition to outstanding mentors. At Purdue, the Graduate School has enlisted the provost to present graduate mentoring awards to a couple of faculty members during a formal ceremony which is held annually. This award recognition helps reinforce the importance we place on quality mentoring.

Finally, we’ve found tremendous value in having mentor training. Every new faculty member is required to attend a mentoring workshop run by the Graduate School. During the workshop, we cover all the essential elements of effective mentoring, career counselling, strategies for staying current, avoiding pitfalls, promoting student success, and more. This has helped provide a more uniform level of mentoring across all disciplinary and interdisciplinary programs.

Innovations in Interdisciplinary Learning: Electronic Resources for Learning and Research

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ProQuest Information Solutions

Introduction

Interdisciplinary learning and research is a growing area for government investment^{1,2} and many institutions are following suit by reorganizing departments and establishing interdisciplinary research centers.³ What is clear to many in the higher education community is that, in order to develop and support interdisciplinary research, new infrastructure and resources are needed to help emerging scholars thrive in this new landscape.

Today I will share how ProQuest, is supporting interdisciplinary learning and research, and how we envision fostering interdisciplinary research growth. To help orient you, it is useful to think of ProQuest as a large information aggregator. We collect and render for our users vast amounts of information, from today's New York Times front-page articles, to digitized editions and audio plays of William Shakespeare, and from groundbreaking research published in the New England Journal of Medicine, to a PhD dissertation in Anthropology from the University of New South Wales. We bring this information together into a common but customizable online platform that delivers improved research experiences to our user base in universities around the world. We are part of a market of information aggregators, such as JSTOR, and public resources such as PubMed Central.

Supporting Interdisciplinary Research and Learning

We believe the following are necessary in developing electronic resources for interdisciplinary research and learning:

- **Breadth of information:** Interdisciplinary research, by definition, spans different subject disciplines and different content domains. As such we believe that electronic resources that support interdisciplinary research must draw content from across the disciplines being supported. In supporting interdisciplinary research, we draw from sources spanning science, medicine, humanities, business, political sciences, social sciences, arts and literature—delivering information to researchers from fields adjacent to their areas of expertise and bridging gaps between traditionally disparate disciplines of study.
- **Source of information:** Interdisciplinary research may need to draw from a range of content sources, reflecting where valuable information resides in different domains. In some areas such as life sciences, scholarly journals can be a primary source for information exchange. However, information consumption can vary by discipline: economics researchers may use

¹ Basken, P. "National Science Foundation Steps Up Its Push for Interdisciplinary Research," *The Chronicle of Higher Education*, Feb 13, 2012.

² Petrie, M., "NIH Seeks to Foster Interdisciplinary Research," *The Chronicle of Higher Education*, Sep 21, 2007.

³ Jacobs, J., "Why the Disciplines Still Matter," *The Chronicle of Higher Education*, May 27, 2014.

conference proceedings more regularly, physicists often rely on preprints, and humanities disciplines typically utilize monographs in greater proportion than sciences.⁴ Primary sources such as government documents, historical news, and data, can be essential to certain disciplines. At ProQuest we seek relevant, trusted content that has been vetted through review processes, while at the same time being agnostic to content type (e.g. journal, book, dissertation, news).

- **Removed silos.** As an information provider, we are often oriented to manage our information sources by discipline specialty, which can limit interdisciplinary research. Increasingly, we are challenging ourselves to open large content swaths for research. We see ourselves and other providers increasingly offering access to their entire collections and developing new access models, such as Demand Driven Acquisition, a popular model from E-Book publishers.
- **Delivered Insights:** The dawn of “Big Data,” and the computational and analytical tools that can mine content in text or data format, have proved a catalyst for interdisciplinary research in unlocking hidden information and developing new knowledge. For example, ProQuest recently supported a team of historians, information and computer scientists spanning five organizations to identify historical trade routes by mining over 10 million historical document pages. The research identified plausible historical trade routes, with citations back to the historic content for further validation.⁵ This is one example of how computational power can foster interdisciplinary research insights. E-resource providers must determine what their role will be in delivering such insights. It can extend from content provision, through open platforms that support text and data mining, to software and analytics, to solutions that will improve researchers’ outcomes.

Future Directions

Looking to the future, we see several areas in which further development by e-resource providers will accelerate interdisciplinary studies:

1. **Fostering collaboration:** To facilitate and accelerate research and learning in disparate departments and environments, and to create workflow tools that need to be embedded at the point of information use. For example, for e-resource providers, greater inclusion of reference management tools and document sharing with peers, alongside the utilization of information, could foster information exchange and collaboration.
2. **Creating serendipity.** Information providers have the potential to inject interdisciplinary opportunities into research workflows. Recommendation engines have the potential to identify analogous research conducted in different domains, as well as individuals and cohorts from other domains who have mutual, but previously unrecognized, interests.

⁴ Tenopir C., Volentine R, King D.W. “Scholarly Reading and the Value of Academic Library Collections: results of a study in six UK universities.” *Insights, the journal of the UKSG (formerly Serials)*. 25(2):130-150, 2012.

⁵ See: <http://homepages.inf.ed.ac.uk/balex/publications/slides-ProQuest.pdf> for an example of interdisciplinary research supported in part by ProQuest.

3. Providing new modalities to experience information. Just as the migration from print to online has provided new dimensions in which to access and experience content, e-resource providers must look to the future and provide new ways for individuals and teams to interact with content beyond the reading of text. Areas of development include incorporating audio and video content into e-resource platforms, interactive tools to query content and data sets, and tools for visualizing content in multidimensional formats.

Conclusion

The emergence of interdisciplinary studies creates exciting opportunities for new discoveries as scholars reach across multiple fields of study to follow their interests and passions. We believe e-resource providers such as ProQuest have an important role in bridging the breadth of research information and an array of content types from adjacent and disparate fields to support research endeavors, while also breaking silos and delivering insights. As we evolve in our support of interdisciplinary research we will foster collaboration, create serendipity and deliver new modalities in which to experience information and improve knowledge discovery.

5: Structures for Interdisciplinary Research and Collaboration

The Advantages of an Interdisciplinary Structure: Griffith University as a Case Study

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Griffith University, with five campuses spread across the Brisbane-Gold Coast corridor and home to over 43,000 students (1,800 higher degree research students), is just 40 years old. It was established in 1971 and officially opened in 1975. Its foundation was based on a deceptively simple brief: to offer an alternative university experience to that already available in Queensland and other parts of Australia.

The original Griffith Council developed a philosophy, not only to provide specialized academic courses, but also to emphasize the general educational development of students. Central to this was the creation of theme-oriented schools. These schools were multi-disciplinary with groups of disparate scholars integrating their research and teaching in problem-solving units. For example, Griffith was the first Australian university to offer Environmental Science and Asian Studies degrees.

It was the interdisciplinary structure that attracted me to Griffith University in 1990 to start my academic career (as a Lecturer in Chemistry in the School of Science) as I viewed it as the ideal environment to develop my interdisciplinary research interests in biological inorganic chemistry. The structure facilitated the interactions between scientists with diverse research interests. I witnessed many occurrences of innovative new interdisciplinary projects stemming from conversations in the single common room, which was located between the three buildings that housed academics interspersed in offices across the breadth of STEM disciplines in chemistry, physics, mathematics, biology biochemistry, IT and microelectronic engineering. In 2001 I moved to the University of Western Australia, as the foundation Professor of Biological Chemistry, and was struck by the contrasting barriers to developing interdisciplinary collaborations from the confines of a single discipline Department of Chemistry in a traditional, well-established university.¹

One example of the success of the original Griffith structure in fostering interdisciplinary research has been the work of my colleague Professor Ron Quinn, an organic chemist specializing in marine natural products, who is director of the world renowned Eskitis Institute for Drug Discovery.² The Institute searches for and develops new drug- and cell-based therapies in areas such as cancer, infectious diseases, neurological diseases and global health. It began life in 1988 with the establishment of three research centres within Griffith University aiming to undertake early stage drug discovery, neurobiology and cell biology research. The research

¹ I returned to Griffith University in 2009 to take up the role of Pro Vice Chancellor (Science, Environment, Engineering and Technology) before moving to my current role as Dean of the Graduate School in 2012

² See <http://www.griffith.edu.au/science-aviation/eskitis-institute>.

is supported by the unique Nature Bank resource,³ a storehouse of chemical diversity from the natural world which encompasses a library of over 200,000 optimized natural product fractions derived from a diverse collection of over 45,000 samples of plants and marine invertebrates. The Institute provides an outstanding environment for interdisciplinary graduate research and currently hosts 59 higher degree research students with around one third from outside Australia.

A further case study for how the Griffith University structure has fostered the growth of interdisciplinary research and collaboration across STEM disciplines is exemplified by the career of Mark von Itzstein, who was a graduate of one of the first cohorts of students in the interdisciplinary School of Science at Griffith, going on to complete a PhD in chemistry in 1985. He subsequently joined the Department of Medicinal Chemistry, Monash University, as an independent research leader and led the chemical biology research program that discovered the anti-influenza drug, Relenza®, for which he was jointly awarded the Australia Prize in 1996.

In 2000, Prof von Itzstein returned to Griffith University to establish and head the Institute for Glycomics,⁴ which is one of only a few multi-disciplinary glycoscience research centres in the world. The Institute provides a multidisciplinary approach to drug and vaccine discovery research as well as a multidisciplinary approach to research and education, spanning medicinal and computational chemistry, various biological and physical sciences. This approach presents an exciting platform for the control of a wide-range of medical conditions such as cancer, diabetes, infectious diseases, inflammation and immune disorders.

The Institute for Glycomics has a broad scientific staff profile of approximately 150 researchers including a cohort of > 35 PhD students. As for the Eskitis Institute for Drug Discovery, the Institute provides the ideal environment to prepare the next generation of research professionals to conduct research and collaborate beyond the bounds of one discipline. Interdisciplinary collaborations develop naturally and joint supervision arrangements are readily put in place by having a critical mass of researchers, from disparate disciplines, focused on a common goal to bring forward novel drugs and vaccines to the community. The graduate students have access to state-of-the-art co-located research facilities covering biology, chemistry and the structural and analytical sciences that enables research translation from bench to bedside.

³ See <http://www.griffith.edu.au/science-aviation/eskitis-institute/nature-bank>.

⁴ Research at the Institute for Glycomics, is based, in part, on the study of carbohydrates or sugars (*glyco* – the Greek prefix for sugar). Carbohydrates are involved in many biological processes and particularly in disease. See <http://www.griffith.edu.au/science-aviation/institute-glycomics>.

Perspectives from Science, Technology, Engineering and Mathematics (STEM)

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Interdisciplinary research enjoys an elevated status among university administrators and funding agencies. There are several compelling reasons for this, with the primary one being that many complex, hard problems do not respect disciplinary boundaries. The solutions to such problems will necessarily draw upon insights from multiple fields. Moreover, interdisciplinarity allows for creativity in novel, unpredictable ways. Also, there is a strong belief that new breakthroughs will occur at the interfaces of disciplines. That is where the limits of disciplines are stretched and are likely to experience advances in the state of the art.

However, the actual process of conducting interdisciplinary research is not easy. There are many barriers faced by institutions, faculty members and students. The institutional barriers mainly arise from the disciplinary structure of most universities within which academic territories are neatly demarcated. More importantly, resource allocation is usually determined by such structures. Finally, credit sharing is also influenced by the disciplinary structure of the organization. For faculty members, most journals and conferences are organized by discipline. While there are new interdisciplinary forums being established, the most prestigious ones tend to be the *intra*-disciplinary ones. Therefore, for obtaining peer recognition as well as for tenure and promotion decisions, there is a tendency to favor research *within* the discipline. Similar considerations exist for students. For them, there is also the additional factor of finding jobs for which there are fewer interdisciplinary units when compared to the traditional disciplines.

At NUS, we have tried to mitigate such barriers by creating institutional mechanisms to support interdisciplinarity. We decided to organize some of the larger research efforts around integrative clusters, many of them related to STEM fields:

- *Finance and Risk Management*: seeks to create fundamental and use-inspired research that can also contribute to Singapore's goal of becoming a leading financial center in Asia.
- *Translational Biomedical and Clinical Research*: aims to be a leader in medical and public health research, especially for diseases more common among Asians or with a different pathology in Asian ethnic groups.
- *Active Ageing*: carries out research that develops technologies, informs the formulation and execution of policies, which will lead to better culturally-aware strategies for healthy ageing.
- *Energy and Environmental Sustainability*: focuses on a wide range of research questions spanning exploratory science to future technologies to policy implementation and it is coordinated by the NUS Energy Office.
- *Global Asian Studies*: This cluster aims to take the lead in research and scholarship directed at topics pivotal to Asia's future. By focusing on integrative studies, the work will go beyond public policies and also deal with matters of technological importance.

- *Materials Science*: organically arose from a convergence of research strengths in science related to graphene and Nanoscience with the Nanotechnology efforts in Engineering.

These research efforts have been complemented by building strong interdisciplinary graduate programs:

1. NUS Graduate School of Integrative Science and Engineering (NGS). Established in 2005, NGS has grown from an initial enrolment of 31 PhD students to a total of 480 today. It has introduced an innovative interdisciplinary coursework curriculum combining skills workshops, immersion courses and education in ethics and integrity. Particular care is taken in recruiting students who:

- have a keen interest in integrative approaches to research,
- enjoy taking an analytical approach to problems,
- seek to deepen their knowledge in a focused research area but, at the same time, are aware of, and are interested in, a wide range of topics in science and engineering,
- adhere to the very highest ethical standards,
- appreciate the importance of developing excellent communication skills,
- are able to work independently whilst appreciating the value of team work and,
- can serve as role models to future generations of researchers and hopefully make an impact in their chosen fields of study.

Students are strongly encouraged to transcend traditional disciplinary boundaries in their doctoral work. PhD advisors at NGS are specially chosen via a stringent selection process that vets academic ability, interdisciplinary interest and track record of guiding students. The students are required to have thesis committee members from different disciplines. The coursework is tailored to the individual student's needs. By taking courses and carrying out lab rotations early on in the program, students have the opportunity to acquire new knowledge and tools in areas related to their doctoral research. Life scientists can gain proficiency in computation, physicists and engineers can acquire knowledge of biological concepts, and medics can learn about the molecular basis of disease. Every student has to do a compulsory course on "Interface Sciences and Engineering." It consists of a series of lectures/discussions/presentations that would provide students with an interdisciplinary exposure and knowledge foundation for selected research themes that are of prime importance to humankind, and where interdisciplinary science and engineering are frequently practiced. Each theme is taught and coordinated by two instructors who contribute to different, yet complementary, perspectives of the theme—such as "Infectious Agents and Global Pandemics," "Omics," "Renewable Energy," "Human-Computer Interactions" and "Environmental Problems/Climate Change."

2. Interdisciplinary PhD Programs: are also offered by the Centre for Quantum Technologies, the Mechanobiology Institute and the Cancer Science Institute of Singapore. These are nationally important research centres of excellence on the NUS campus. These Interdisciplinary PhD programs also help us attract top graduate students who in turn are highly important to the success of such multi-disciplinary research projects (in a virtuous cycle). These numbers are relatively small as compared to NGS.

Finally, NUS has encouraged and facilitated interdisciplinarity by consciously engaging in its practice of:

- Providing enablers and incentives from our internal resources (e.g. seed funds, priority access to research space, PhD scholarships) to groups willing to work across disciplines.
- Establishing coordinating offices such as the NUS Energy Office and Maritime Institute @ NUS to coordinate research programs across NUS and liaise with external stakeholders in energy research and marine offshore research respectively.
- Regularly engaging government agencies and national research funders to understand their priorities and research needs, particularly for holistic, multi-disciplinary solutions. We then share these insights with the relevant Schools/Faculties and assist them to strategize/organize into multi-disciplinary teams that are well-positioned to respond to these national calls for proposals.
- Factoring these considerations into our campus infrastructure planning so that new buildings are designed to encourage interactions and synergy across divisions and disciplines.
- Recognizing and rewarding interdisciplinary research during tenure and promotion considerations. Multi-author papers spanning disciplines are particularly recognized.
- Supporting an on-going mechanism to identify and develop future peaks of excellence. For example, the area of “Human Nutrition & Development” is currently being considered.

Thus, NUS has adopted a two-pronged strategy of developing institutional mechanisms for facilitating interdisciplinary research which are complemented by a strong suite of graduate programs.

Bridging Gaps Between Science and Engineering

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Doctoral Education at TUM

As a Technical University, or Institute of Technology, Technische Universität München (TUM) has a research and education portfolio which is not only focused on science and engineering but also covers life sciences, medicine, and economics. To understand a university-wide framework for doctoral education not as a restriction of disciplinary variety, but as a unique chance to both enrich traditional disciplinary paths and increase quality of education, has been one main pillar in the design of TUM Graduate School (TUM-GS). Established in 2009 as an optional program and since January 2014 mandatory for all doctoral candidates, TUM-GS today is the home to doctoral education across all thirteen departments at TUM. TUM-GS acts as an umbrella organization with currently 26 Graduate Centers providing tailored programs that mirror its regulations. Among these, 14 Department Graduate Centers attend to the disciplinary doctorates and 12 Thematic Graduate Centers foster interdisciplinary doctoral education. The most important of the latter is IGSSE, the International Graduate School of Science and Engineering.

IGSSE and its Structure

Built upon project teams operating at the interface of the natural sciences, engineering, and medical research, the International Graduate School of Science and Engineering combines exceptional research approaches with an outstanding doctoral education program. All project teams at IGSSE link basic science to engineering paths and give young researchers the opportunity to join scientific forces across the classical disciplines. This concept has won highly competitive funds of the German Excellence Initiative in 2006 and 2012.

Besides the unique opportunity for PhD candidates to either learn the language of a natural scientist or learn to understand the thinking of an engineer, they have access to about 200 courses on topics such as entrepreneurship, personal development, project management, and many more. These courses—offered each term—are tailored to the needs of PhD candidates, most of them provided by TUM-GS. IGSSE especially fosters international collaborations via a compulsory 3-month stay abroad and its annual forum with international guest researchers.

As IGSSE project teams do cutting-edge research off the beaten track, they are expected to act as incubators for emerging research fields of strategic importance to TUM. This, of course, calls for a strict and transparent granting process. Up to twice a year, IGSSE calls for new project proposals, conceived by at least two senior scientists from different groups and departments (e.g., natural sciences, engineering, medical sciences) at TUM. Since 2007, more than 80 project teams have commenced their work within IGSSE.

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Project Teams

An IGSSE project team comprises at least four doctoral candidates, a young postdoc (project team leader, PTL) heading the group, and two or more senior scientists as PI's, representing a synthesis of science and engineering. If suitable, master's students are welcome to join the team, too. After the individual project kick-off meeting, all teams discuss their research results in project team sessions, held on a regular basis. IGSSE has funds available for project issues, for all doctoral candidates involved, as well as for the PTL. Since its foundation, more than 280 doctoral candidates from next to all TUM departments have done research within IGSSE.

Cornerstones of the IGSSE Educational Program

IGSSE encourages its PhD candidates to broaden their disciplinary and personal horizons through its educational program. The starting point is a supervision agreement, ensuring a PhD project roadmap. After two years, the development and quality of the dissertation phase are certified by an interim evaluation. In addition, all IGSSE PhD candidates have to complete four training modules complementing their dissertation phase. 50 credit points have to be collected via (1) disciplinary training (summer schools, scientific workshops, etc.), (2) scientific skills training (paper elaboration, teaching, etc.), (3) a three-month research stay abroad, and (4) transferable skills training (entrepreneurial know-how, presentation skills, ethics, personality training, etc.).

As an *international* graduate school, scientific activities abroad are supported via additional grants. The active participation in conferences and especially the research stay abroad at a foreign lab are vital parts of IGSSE's qualification program. Both activities have proven to establish new international networks and stimulate joint publications.

Regarding the *interdisciplinary* approach, IGSSE supports trans-disciplinary lectures and workshops both in Munich and outside Germany. To give some examples, in October 2013, IGSSE supported a cross-department delegation to attend the Leichhardt-Symposium in Australia; in May 2014, IGSSE supported doctoral candidates in organizing the first lecture of a cross-departmental series. An interdisciplinary highlight is IGSSE's annual meeting at the Raitenhaslach monastery in Burghausen, where networks across all project teams and a true interdisciplinary spirit develop. During this three-day symposium, about 200 IGSSE members meet with international guests in scientific workshops, lectures, and ambitious training programs. "I would say the combination of such fabulous people and quality outreach is what makes the IGSSE the state of the art and at the forefront of the international scientific networking. This is immensely rewarding and posits inspiring research coordination," said Dr. Mohamad Araji, Environmental Design Program, University of Manitoba, about the graduate school's meeting in 2014.

Experiences

So far, IGSSE doctoral candidates have benefitted a lot from its concept. IGSSE has been able to support research stays around the globe—at MIT, ETH Zurich, National University of Singapore, University of Berkeley, or the Scripps Institute, just to name a few. The feedback has always been extremely positive, with respect to both research and personal skills. But keeping up with the interdisciplinary idea has not always been an easy task. Besides the classical reservations concerning trans-disciplinary research, especially the PTL model is sometimes problematic.

Although in a responsible position, the young postdocs are at a career stage that requires mobility and sometimes implies leaving TUM and their IGSSE doctoral candidates behind. As it was difficult to find appropriate replacement for these postdocs, some teams could not find a way to continue their regular meetings. IGSSE responded to the problems with extra funds for PTLs, to be used for their personal career development and special training offers.

A recent example of the successful link of doctoral education and interdisciplinary research is the project “Coating of Stent Surfaces,” closed successfully in July 2014. Conceived by a TUM chemistry chair and a heart surgeon of Deutsches Herzzentrum in Munich, the aim was to improve stents for heart surgery. The involved doctoral candidates published 22 peer-reviewed papers, 6 of which were first-author ones, and filed 3 patents. All of them received a broad range of high-profile job offers and are now working for international companies and German national research institutes. Regarding IGSSE’s aim to foster innovative research, some project teams succeeded in acquiring grants for new research proposals (EU funds within the FP7 program, e.g.), some have fostered TUM’s international collaborations (e.g. Solar Decathlon 2015).

With more than 90 Alumni, now working as professors (e.g., in the USA, Germany, or China), research fellows (e.g., in the USA, France, or Germany), lecturers (e.g., in the UK), as well as senior project managers in industry and science or as entrepreneurs, the graduate school has met its expectations to prepare young scientists for leadership positions in both academia and industry.

Interdisciplinary Research and Collaboration in Education and Engineering

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The main purpose of interdisciplinary learning and research is to make sure that the eventual outcome will be relevant to both society and for human life betterment. This will close the gap between higher education institutions and society needs. Education can fall in the humanities or Social Science research area. If Social Science is viewed from a methodological perspective, Social Science is the field that applies scientific methods to study the human aspects such as human behaviour and social order. On the other hand, the humanities involve analytical and critical approaches. Despite the differences, education can fit in both disciplines, where educational research can investigate how humans learn as in social sciences discipline or educational research can be carried out on how to teach art lessons, which can reflect a humanities discipline. Eventually, as both disciplines are related to humans, it opens up windows for integration and the possibility for integration by other research areas as well such as Engineering.

As one of the pioneer and premiere universities in Malaysia that focuses on the Engineering field, Universiti Teknologi Malaysia, has produced more than 150,000 Engineering and Science and Technology graduates. Most of the graduates held top administrative positions such as CEOs, managers, or leaders in companies and organizations. With the increasing education trend where societies apply the “back to school” concept, there has been increasing number of engineering graduates that pursue their studies at the graduate level. This group of people, consisting of CEOs, leaders or managers, favors interdisciplinary programs such as Innovation in Engineering, Engineering Business Management and etc., where Engineering is integrated into the social sciences and humanities. This integration is a very good opportunity to enrich and add value to the field of social sciences and humanities. More discussions can be carried out to further explore new areas of integration. These discussions will provide better understanding on how the social sciences and humanities can better operate.

Challenges and Opportunities within the Disciplines:

However, although such unification seems feasible and practical, there are also challenges in the integration. One of the main interdisciplinary challenges within humanities and social sciences is the understanding of the differences existing between sub areas in the discipline itself. For example in the Education research area, scholars from Foundations of Education claim that they have better comprehension of theories of learning as compared to those from the Applied Education field such as Educational Technology and Science, Technology, Engineering, and Mathematics (STEM). However, one has to be aware of the fact that, someone who is well-versed and is an expert theoretically is not necessarily an excellent practitioner. In a teaching and learning context, good comprehension about learning theories without having the ability to implement those theories is insufficient for a good educator. We have to be reminded that some

theories need adjustments to the learning settings, students' needs and preferences, as well as adjustments to fit into the content of teaching and learning. If we can minimize the challenges, interdisciplinary opportunities within the disciplines will be expanding as many experts speak a similar language.

Challenges and Opportunities across the Disciplines:

The social sciences and humanities are two disciplines that have the possibility for integration with other disciplines. According to Moran (2010), interdisciplinary remains humanities-driven or necessitated. It has widened the opportunities for the humanities and social sciences disciplines to be integrated with other technical disciplines. Considering the integration of these disciplines and other technical disciplines will serve its own purposes such as:

- To prepare graduates for life in complex and demanding societies and world.
- To fulfil the need of the current program where the focus of current graduate curriculum is on interdisciplinary program.
- To provide more relevant academic programs to adult learners, where most of them are CEOs, managers, or experienced workers of companies coming back to school and looking forward to enrolling in interdisciplinary programs.
- To broaden and sustain the roles of institution. Interdisciplinarity is important for the survival of the discipline—such as in Engineering—interdisciplinary between Business and Engineering will increase the sustainability of the field. As in UTM, our strength is on Engineering and Science and Technology programs and to continue to be the expert in these areas, we have introduced quite a number of interdisciplinary programs such as Engineering Business Management, Engineering Education, Professional Science, Innovative Management in Engineering, Halal Science, etc.

As educators, we have been organized in department-based structures and disciplinary knowledge domains. Therefore, it is a challenge for us to understand interdisciplinary knowledge. Challenges to introduce such interdisciplinary programs, learning, and research can be observed from two different perspectives. From the perspective of the social sciences and humanities, social scientists and humanists will look into how the initiatives will benefit the human condition and therefore they are not going to tolerate any obstacles or limitations due to other factors. However, from the perspectives of other disciplines such as Engineering and Computer Science, the scientific factors are the main focus. With that focus in mind, the question of whether the initiatives such as theory, products, or frameworks will benefit users are not their main interests. This mismatch has created intensive debate among the experts, which is leading everyone to a dead end. Interdisciplinary learning requires experts to understand it from the interdisciplinary context (Moran, 2010).

What structures for interdisciplinary learning and research have proven to be particularly successful within and/or across these fields?

A Few important aspects that have to be considered by the interdisciplinary scholars among faculty members are processes, outcomes, and motivations. First, to assist academicians to understand interdisciplinarity, the structure of the institution must be transformed. According to Holley (2009), the existing institutional structure is only based on the disciplinary knowledge domain where higher education is unable to support interdisciplinary work. The existence

of interdisciplinary structures is thus, required. For example at UTM, to run the Engineering Education Doctoral program, the university has opened the Centre of Engineering Education to initiate the program and play the role of an interdisciplinary organization to put experts from two different fields; Engineering and Education together. At the Centre, experts from both fields share the same goals to engineer the interdisciplinary program. They negotiate ideas and they have to create a mutual understanding so that both Engineering and Education can sit in the same boat. They also have to look for areas at which Engineering and Education can intersect. The intersections help the Center to open up areas of research under the interdisciplinary program. Holley (2009) posted some questions related to challenges that we have to face in introducing interdisciplinary programs. The questions are:

1. How does interdisciplinary research affect standards of faculty tenure and promotion?
2. How do colleges and universities encourage integration among students and faculty located in separate, often isolated departments?
3. How do institutions construct an interdisciplinary course of study that requires students to interact with faculty and areas of knowledge from multiple disciplines?
4. What cognitive, cultural, and social challenges exist as scholars seek to achieve an integrative synthesis?

Therefore, changes in strategies to meet the challenges are suggested by the experts such as:

1. Lattuca (2001) suggested institution to include an action examining tenure and promotion criteria
2. Palmer (2001) suggested institutions alter departmental structures
3. Amey and Brown (2004) mentioned that institutions need to institute collaborative leadership for interdisciplinary activities
4. Klein and Newell (1996) suggested institutions need to experiment with curricular requirements.

Based on our experiences in managing interdisciplinary graduate programs, here are some of the structures:

1. Initiating a unit such as a Centre or Academy that is based on an interdisciplinary nature.
2. As for full research graduate programs, the use of a panel of supervisors consists of 2 to 4 supervisors with different expertise such as a professor in Engineering, a professor in Education, a supervisor from industries, and an expert from a government agency. Using this supervision model, not only will the graduate research fulfil the needs of academic research, but the research findings can be directly applicable to society. This will indirectly solve a particular problem in higher education, where the involvement of industries in a graduate research is frequently questionable.
3. Team-teaching for interdisciplinary courses where the involvement of experts from industries through part-time appointment is encouraged.
4. In UTM, to support interdisciplinary learning across courses, the concept of New Academia, where the transformation of the concept of academia has taken place as the following:

	New Academia	Action
Faculty members	Professors, inventors, entrepreneurs	Adjunct staff, fellows
Learning materials	Books, journals, experiences, Internet, Internship	Internship, students' business ventures
Philosophy	Integration	New pedagogy, Research Alliances
Funding	Grants, fees, VC, endowment	Creative fund raising
Students	School leavers, mid-career, businessmen, early-career, life-long	Top Undergraduate, Postgraduates from corporations, research
Venue	Campus, Internet, incubators, brands	Wifi, 4G, MTDC, Proton
Learning models	Lecturers, tutorials, lab, studios, internship, incubators, experiential learning, 5 minds	NEW PEDAGOGY: learner-centric, Silicon V-culture, GOP, ethics
Outcomes	Degrees, expertise, business models, capital, networks, culture	JOB CREATION; micro-credit, spin-off, projects

Source: Ujang, Z., (2012). New Academia UTM as a Global Brand. Johor: UTM Press.

5. In UTM, rationalization of departments, where two departments have been merged together to build a new interdisciplinary department.
6. Conducting support programs to prepare faculty members for interdisciplinary scholarship so they will better understand the needs and purposes of interdisciplinarity.

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Academic and Graduate Program Structures for Fostering Interdisciplinary Research

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Vice Provost and Dean of the Graduate School
Cornell University (United States)

Cornell University takes a multi-faceted approach to encourage meaningful scholarly engagement among disciplines in graduate education and in research more generally, driven in part by the institution's long-standing commitment to discovery-driven and problem-based research with a focus on translation and application to benefit society. We do this through graduate program structures at the level of students' graduate committees and in the purposeful intellectual and operational design of graduate programs, through cross-cutting research centers established with external and institutional funding, and through targeted activities designed specifically to cultivate interdisciplinarity.

Structure of Graduate Fields (Programs) and Graduate Committees

Graduate academic programs at Cornell are interdisciplinary by design. Graduate fields (programs) through which graduate degrees are offered are voluntary groupings of members of the university graduate faculty who have scholarly interests in common and who wish to exercise shared responsibility for an area of inquiry and for the admission, education, and financial support of graduate students. Graduate fields are independent of traditional college or department structures, so they may draw together faculty members from several disciplines in accordance with scholarly interests. The majority of graduate faculty are members of more than one graduate field; some graduate faculty are members of as many as six graduate fields.

Research doctoral students are required by faculty legislation to include at least three graduate faculty on the doctoral advising committee (called the special committee), representing one major and two minor areas of study. Most special committees include faculty from two or three graduate fields; often the special committees include faculty spanning two or more of our four categories of broad disciplines (humanities and arts, life sciences, physical sciences and engineering, social sciences). This structure encourages students to develop disciplinary depth and multidisciplinary breadth, and creates opportunities for faculty across disciplines to build active scholarly relationships. Our newest graduate education campus, Cornell NYC Tech in New York City, goes a step further by requiring that graduate advising committees include academic faculty and industry/business advisors, further stimulating cross-pollination not only across disciplines but also across academic and entrepreneurial/corporate cultures.

Multi-disciplinary Research and Engagement Centers

Cornell has more than 100 interdisciplinary research organizations (centers and institutes) whose mission is to bring together faculty and students from across the university to pursue research, teaching, and outreach on broad scholarly and socially-relevant topics. Most of these centers and institutes were created to align with national and global needs, providing direct benefits to individuals, groups, and society. Our centers and institutes are supported with a mix of external (e.g., federal, foundation) and internal institutional resources.

Among these, we have two national research centers serving broad national and international scientific communities and reflecting partnerships of academia, government, and industry: Cornell High Energy Synchrotron Source (CHESS) and Cornell NanoScale Facility (CNF). CHESS, a high-intensity X-ray source, was recently renewed by the National Science Foundation with a five-year, \$100-million award, and provides state-of-the-art synchrotron radiation facilities for research in Physics, Chemistry, Biology, and Environmental and Materials Sciences. Through this facility, Cornell graduates roughly 20 percent of the nation's PhD's trained in accelerator science and advanced X-ray technology.

Other research centers and institutes bring faculty and students together across disciplines to address the study of economy and society, sustainability, energy systems, inequality, and other cross-cutting societal challenges (<http://www.cornell.edu/research/centers.cfm>). One example is the Atkinson Center for a Sustainable Future (ACSF), whose mission is to advance interdisciplinary research in Energy, the Environment, and Economic Development and cultivate innovative collaborations within and beyond Cornell to foster a sustainable future for all. The ACSF employs a variety of strategies to promote interdisciplinary collaborations engaging graduate students, postdocs, and faculty, including a competitive academic venture fund, topical discussion groups, faculty fellows across campus, and an actively engaged faculty advisory board with membership spanning many disciplines. ACSF focuses its efforts on six priority problem-driven areas, including agriculture and food systems, energy transitions, one health, sustainable communities, new materials, and computational sustainability.

Interdisciplinary Program Efforts

One example of strong interdisciplinary programs is Cornell's Society for the Humanities (<http://www.arts.cornell.edu/sochum/>), established in 1966. The Society gathers graduate students, postdocs, faculty, and distinguished visitors to pursue research on broadly interdisciplinary focal themes, producing path-breaking interdisciplinary dialogues, theoretical reflections, and frameworks for possible societal responses. The Society sponsors special theme projects through which to frame and focus its efforts annually; recent themes have included Sensation, Risk, and Water. The focus on Risk, for example, reflected on historical, theoretical, and global understandings of risk, drawing from approaches in the humanities, life sciences, economics, and technology. The Water theme encouraged participants to cross disciplinary boundaries by considering water as a "an object of conflict and contest, as boundary, as divider of regions and cultures, ... a source of life and wealth, and as a medium of communication, migration, transport, commerce, and redistribution." Theme projects, by design, pose questions from multiple perspectives and employ approaches for bridging disciplines. Many of the Society's faculty and graduate students are active members of the Humanities, Arts, Sciences, and Technology Advanced Collaboratory (HASTAC) (<http://www.hastac.org/about>), an influential community of graduate students, faculty, and others working at the intersection of the arts, humanities, engineering, and sciences through creative use of technology.

Lessons Learned

Purposeful structures can be designed and implemented to enhance the likelihood of creating opportunities for intellectual collisions, resulting in ongoing interdisciplinary dialogue and collaborations. The potential for success of these structures is enhanced through strategic deployment of funding, space, and other resources, and fostered through the vision and commitment of one or more vocal and respected faculty champions.

6: Building and Sustaining External Partnerships

Federal Funding Sources for Interdisciplinary Graduate Training in the U.S.

Maureen Terese McCarthy

**Assistant Director of Advancement and Best Practices
Council of Graduate Schools**

The U.S. Funding Landscape: Research v. Training

In the United States, federal funding is dispersed unevenly for interdisciplinary *research* and for interdisciplinary *training* of students. Federal funding agencies in the United States have long recognized the value of funding interdisciplinary research for faculty, particularly in scientific and medical fields. Although there are too many to name individually, a few examples include:

- The National Academies Keck Futures Initiative has annually convened researchers on a rotating cross-disciplinary theme since 2003.¹
- The National Institutes of Health (NIH) funded nine university-based interdisciplinary research consortia through its Common Fund (also known as the NIH “Roadmap”) from 2005-2012.²
- The National Science Foundation (NSF) continually funds both solicited and unsolicited interdisciplinary research projects, particularly in designated “Areas of National Importance,” as well as research channeled through one of its many Science and Technology Centers.³

Although less varied opportunities exist at the federal level for funding interdisciplinary research *training*, some clear avenues do exist. The NSF Graduate Research Fellowship Program is expanding its training elements that fund fellows’ research-related travel and other enrichment activities.⁴ Historically, NIH has invested heavily in building the biomedical research workforce and its diversity, including with new initiatives on innovations in graduate training and a “Big Data to Knowledge” program, and numerous graduate students have been supported on NIH Roadmap projects. By far the most sustained federal initiative to fund interdisciplinary research training, however, has historically been the National Science Foundation’s Integrative Graduate Education and Research Traineeship (IGERT) program. A consistent source of funding for graduate student training for 18 years, IGERT was re-imagined this year (2014) as the NSF Research Traineeship (NRT). A brief outline of the NRT program follows.

History of the NRT

In 1997, NSF founded the Integrative Graduate Education and Research Traineeship (IGERT)

¹ National Academies Keck Futures Initiative. (2012). The informed brain in a digital world: Interdisciplinary team summaries. Conference proceedings. Irvine California, November 15-17, 2012. Washington, DC: National Academies Press.

² National Institutes of Health. (2012). Interdisciplinary research: Overview. Retrieved from <https://commonfund.nih.gov/Interdisciplinary/overview#>

³ National Science Foundation. (2014). Interdisciplinary research: Introduction. Retrieved from http://www.nsf.gov/od/iia/additional_resources/interdisciplinary_research/

⁴ National Science Foundation. (2014). NSf Graduate Research Fellowship Program Website: About the program. Retrieved from http://www.nsfgrfp.org/about_the_program

to fund STEM-field graduate students for interdisciplinary training and collaboration skills. IGERT awards consisted of about \$3 million for a program spread over five years, including yearly stipends of \$30,000 for PhD students as well as training expenses. Although this program allowed many diverse students to engage in more flexible training than they might otherwise have done, no structures remained to continue offering interdisciplinary training on a larger scale once those students graduated. The training program was limited to the fully funded students within the IGERT program. In order to address this “capacity building” issue, in 2013 the program was reimagined as the NRT program. Although no NRT funds have yet been awarded, NSF anticipates this program will continue for many years into the future.

Selected Attributes of the NRT Program

NRT retains many of the successful aspects of IGERT, but places emphasis on promoting “scalable *models* for STEM graduate student training” (Murthy & Tankersley, 2014, emphasis mine). Like the IGERT, NRT focuses on interdisciplinary STEM research areas. A key difference between IGERT and NRT is a new flexibility. This flexibility is reflected in:

1. An understanding of *training* to include not only research skills but also broad technical skills and career skills not limited to only academic career training.
2. The definition of *trainees* as anyone who completes the components of the NRT program regardless of their funding source. Therefore NRT funds can now benefit a much wider population, including non-U.S. citizens, master’s degree students, and postdocs.
3. The ability of awardees to use NRT funds to build infrastructure for training large numbers of students rather than having to be used to fund individual students.

Notably, the NRT program includes a broader understanding of the career pathways of STEM graduate students. This is an important aspect of any graduate student training mechanism. Current data tell us only the minority of employed U.S. PhD graduates find themselves working at a postsecondary education institution at least ten years after graduation. The numbers range from 23% in engineering to 44% in the physical sciences (and even these figures do not reflect those graduates performing primarily academic research functions, since they include positions such as academic administrators and professors at teaching-centered institutions).⁵ Thus training for a broad range of professional activities seems advised. Beyond these compelling statistics, however, lies a more basic truth: flexible skills drawn from a base of strong interdisciplinary training will strengthen whatever profession these STEM graduate students ultimately pursue, including (but not limited to) academic research.

NRT explicitly encourages “strategic collaborations with the private sector, non-governmental organizations (NGOs), government agencies, museums, and academic partners.”⁶ Some possible forms of this collaboration include the establishment of internship or externship opportunities, or collaborating on the design or delivery of content. No doubt these partnerships will give graduate students exposure to and contacts in sectors beyond academia. Interdisciplinarity seems the ideal location for such relationships—it recognizes the inherent unruliness of a world whose challenges do not respect disciplinary boundaries.

⁵ National Science Foundation. (2010). National survey of college graduates. Public use data.

⁶ National Science Foundation. (2014). Program Solicitation NSF 14-548. Retrieved from <http://www.nsf.gov/pubs/2014/nsf14548/nsf14548.htm>

Interdisciplinary Collaborations with International Partners in Zhejiang University

Jiaping Wang
Executive Dean of the Graduate School
Zhejiang University (China)

Along with the economic globalization, the international dimension of higher education has become increasingly important in the last decade of the 20th century, particularly in the 21st century. Interdisciplinary research now is an international trend of cutting-edge research with the continuous progress and development of science and technology. Practice shows that interdiscipline is the source of generating new disciplines, an important way to get original scientific achievements, also an inevitable choice to solve significant technical and social problems. For example, interdisciplinary outcomes in the Nobel Natural Science Award showed an increasing ratio in the last 20 years. Interdisciplinary collaborations with international partners play an important role in the internationalization of higher education.

Zhejiang University, with a history of 117 years, is one of the leading comprehensive research universities in China. We provide high quality education that prepares our students to be thoughtful leaders and useful citizens with a global vision and social responsibility, as well as in interdisciplinary & innovative research that addresses pressing issues and challenges. With a strong commitment to making a truly international university with academic excellence, it has been making great efforts to develop an international approach with Chinese features. The University has been encouraging the international exchange of staff and students, especially in the field of interdisciplinary collaborations.

Partnership Program to Facilitate Substantial Interdisciplinary Collaboration

Zhejiang University, together with the Massachusetts Institute of Technology (MIT), participates in the development of the Singapore University of Technology and Design (SUTD), Singapore's new publicly-funded university. Partnering with MIT and Zhejiang, SUTD aims to incorporate western and eastern innovation cultures, and to be deeply engaged in the world of ideas, practice and entrepreneurship. Its education and research mainly fall into four categories: Architecture and Sustainable Design, Engineering Product Design, Engineering Systems and Design, and Information Systems Technology and Design.

Zhejiang-California International NanoSystems Institute (ZCNI) was co-established by Zhejiang University and California NanoSystems Institute. ZCNI focuses on nano-materials, biomedicine, and information technology. The cooperation of a cross-platform and related laboratory promote the development of interdiscipline.

Haining international campus of Zhejiang University, which is a platform for transnational education, collaborative research and technology transfer is now under construction. We aim to build a world-class international campus at the forefront of the times, for the mutual benefit of our partner institutions and Zhejiang University. Based on the strengths of all our partner

universities and cultures, they will conduct collaborative teaching, research, and service activities. Those university partners include Imperial College London, University of Illinois at Urbana-Champaign, University of Edinburgh, and Carnegie Mellon University. We are also willing to establish strategic partnerships with more world-class universities.

Going Out and Bringing In Strategy, Participating in Interdisciplinary Research

Qiushi Academy for Advanced Studies (QAAS), Zhejiang University, was established in 2006. Its research work mainly focuses on neural engineering, which is frontier and exploratory. In the last eight years, QAAS has built a solid foundation of high level interdisciplinary research. It has achieved a great reputation and became a prototype of interdisciplinary studies among biomedical engineering, computer science, material science and clinical medicine. Now the study in invasive brain computer interface has been a leading position domestically, and has an important influence internationally.

QAAS insists to extensively carry out international cooperation, which creates a harmonious atmosphere to inspire the young people's innovation to solve practical problems. By keeping the strategy of "going out and bringing in," an innovative training system is well established for graduate students from different backgrounds.

By performing the "going out" strategy, young researchers and students were exchanged with world-class renowned research labs to establish close cooperation in the brain-computer interface field, which helps them have a clear career plan and build self-confidence. At the same time, more graduate students were encouraged to participate in various short-term academic exchanges and international conferences with their academic achievements.

Regarding the "bringing in" strategy, we also actively bring in the frontier international research and employ internationally renowned experts and scholars as visiting professors at Zhejiang University. In 2011, we invited Dr. John Donoghue, whose group developed the first human brain machine interfaces, to be our guest professor. In 2013, Dr. Andy Schwartz, who built the first non-human primate brain-control self-feeding demo in the world, came to visit our lab and spoke highly of our work. By occasionally inviting many renowned scholars to the university and organizing high-level international seminars, we provide face-to-face opportunities for graduate students to meet with top experts and carry out extensive international cooperation. Right now, QAAS has not only formed closer connections with internationally renowned research labs but also attracted an increasing number of passionate research scientists to participate in our research.

Internationalization has become a formidable force and brought to Chinese universities great opportunities as well as challenges. Sharing best practices for world class universities while maintaining a clear knowledge of the situation in China, we will strive to build a broader and higher level interdisciplinary and academic exchanges collaborations with international partners. In that case, we will be in a win-win situation.

Biographical Sketches of Participants

Professor Vahan Agopyan

Vahan Agopyan is Professor of Materials and Components for Construction of Polytechnic School, University of São Paulo, and Vice-President of the University. He is a graduate in Civil Engineering from the Polytechnic School, University of São Paulo (1974), Master of Urban Engineering and Civil Construction from the Polytechnic School, University of São Paulo (1978) and PhD in Civil Engineering from the University of London King's College (1982). Previous activities include Provost for Graduate Studies of the USP, Dean of the Polytechnic School of USP, CEO of the Technological Research Institute of the State of S. Paulo, Vice President of CIB - International Council for Research and Innovation in Building and Construction. Agopyan has research experience in civil construction, with emphasis on materials and components, working mainly with fiber-reinforced materials, recent studies on quality and sustainability of Construction. He is Commander of the National Order of Scientific Merit (Brazil), Distinguished Engineer of the Year (Institute of Engineering), Personality of Technology (Union of Engineers), Honorable Citizen of the City of S. Paulo and member of the Panamerican Academy of Engineering and National Academy of Engineering (Brazil).

Dr. Marie Audette

Marie Audette became dean of the Faculty of Graduate and Postdoctoral Studies (FGPS) of Université Laval (Quebec City, Canada) in 2007 after having been director of the master and doctorate programs in Physiology-Endocrinology at the same university for several years. She is president of the association of deans of graduate studies from the Province of Quebec, ADÉSAQ, and vice-president of the Canadian Association for Graduate Studies (CAGS). She obtained a Ph.D. degree in Medical Biochemistry from Université Laval in 1984 and spent 3 years as a postdoctoral fellow at the Ludwig Institute for Cancer Research in Lausanne, Switzerland, where she studied cancer associated antigens. Back at her Alma mater in 1987 as a scholar from the Fonds de recherche en Santé du Québec, she joined the Laval University Medical Center and the department of Medical Biochemistry. She was member of several granting committees at the national and international levels. As dean of graduate and postdoctoral studies, she has a special interest in promoting excellence in supervision, by supporting faculty members in different ways. Laval FGPS has recently launched a community of practice of (CoP) of thesis directors, enabling its members to share best practices and learn from each other.

Dr. Robert M. Augustine

Robert M. Augustine serves as Dean of the Graduate School at Eastern Illinois University where he holds tenure as Professor of Communication Disorders and Sciences. He is the recipient of the EIU Distinguished Teaching Award, Dean's Award for Service, and EIU Technology Leadership Award. He served as chair of the Department of Communication Disorders and Sciences, as a Visiting International Scholar at Herzen State Pedagogical University of Russia, and as Interim Vice President for Academic Affairs for Technology. Dr. Augustine created the First Choice Graduate Programs initiative that won the Midwestern Association of Graduate School's Award for Excellence in Graduate Education in 2011. He guided development of the Integrative Graduate Studies Institute which won the ETS/CGS Award for Promoting Success in Graduate

Education in 2011. Dr. Augustine's international contributions include launching the Global Ambassadors recognition program, creating study abroad scholarships, and guiding the first dual and joint international degrees. Dr. Augustine earned his Ph.D. from Southern Illinois University at Carbondale. He holds the Departmental Distinguished Alumnus Award from Southern Illinois University and Illinois State University. He currently serves on the Board of Directors of the Council of Graduate Schools holding the position of Past Chair of the Board.

Dr. Sue Berners-Price

Sue Berners-Price completed her PhD in Chemistry in 1985 at Birkbeck College, University of London and moved to Australia in 1987 as recipient of the prestigious Royal Society Florey Fellowship, which she held in the Department of Biochemistry at the University of Sydney. In 1990 she was appointed as a Lecturer in Chemistry in the School of Science at Griffith University (Brisbane, Australia) and then held positions as NHMRC R.D. Wright Fellow (1992–1995), Senior Lecturer (1994–1999) and Associate Professor (2000). She moved to the University of Western Australia in 2001 to take up the foundation Chair in Biological Chemistry. She served a four-year term as Head of the Department/Discipline of Chemistry at UWA and from 2007 was Chair of the UWA Academic Promotions Committee. In 2009 she returned to Griffith University as Pro Vice Chancellor of the Science, Environment, Engineering and Technology (SEET) Group before moving to her current role as Dean of the Griffith Graduate Research School in June 2012.

Professor Berners-Price is internationally recognised for her work in the field of medicinal inorganic chemistry, which involves the design and mechanism of action of gold and platinum-based anti-cancer agents. She holds three patents and is the author of more than 110 peer-reviewed original research articles in top-ranked international journals. She is a Fellow of both the Royal Society of Chemistry and the Royal Australian Chemical Institute, has served on the editorial boards of three international journals, and is currently Associate Editor of the *Journal of Inorganic Biochemistry*. She is a Principal Research Leader in Griffith University's Institute for Glycomics.

Professor Verena Blechinger-Talcott

Professor Verena Blechinger-Talcott (*1966) is Professor of Japanese Politics and Political Economy and Director of the Graduate School of East Asian Studies at Freie Universität Berlin, Germany.

Previous appointments include: Visiting Professor, Institute of Social Science, University of Tokyo (2008), Assistant Professor, Department of Government, Hamilton College, Clinton, NY (2003–2004), Advanced Research Fellow, Program on US-Japan Relations, Harvard University (2002–2003) and Research Fellow (1997–2002) and Deputy Director (2001–2002), German Institute for Japanese Studies (DIJ), Tokyo.

At the FU Berlin, she was Associate Dean (2007–2009) and Dean of the Department of History and Cultural Studies (2009–2011). Since 2009, she has been Head of the FUB's Center for Area Studies. She also is a member of FUB's Academic Senate (since 2013).

Since 2012, she has been Director of the Graduate School of East Asian Studies (GEAS) which is funded through the German Federal Government's Excellence Initiative. The Graduate School brings together 20 faculty from five departments and seven disciplines in an

interdisciplinary doctoral training program. The program combines area studies research with thorough, discipline-based methodological training and strong language and cultural competence.

Verena's research focuses on Japanese politics in comparative perspective. Most recent research has addressed Japan's international trade and global commodity chains.

She is the Speaker of the Advisory Board for Northeast Asia in the German Association of Asian Studies (DGA) and a member of the Editorial Advisory Boards of Japan Forum and Social Science Japan Journal. She also is a member of the International Advisory Board of the Institute of Social Science (ISS), University of Tokyo.

The author of many articles and book chapters, her most recent publication is *Governing Insecurity in Japan. The Domestic Discourse and Policy Response*. London: Routledge (co-edited with Wilhelm Vosse and Reinhard Drifte, 2014).

Professor Hans-Joachim Bungartz

Hans-Joachim Bungartz is a full professor of informatics and mathematics at TUM, where he holds the Scientific Computing chair in the informatics department.

Dr. Bungartz earned a diploma (master's) degrees in mathematics and informatics and a PhD as well as his habilitation in informatics, all from TUM. He became managing director of the Bavarian Consortium on HPC (1996), associate professor of mathematics at Universität Augsburg (2000), full professor of informatics at Universität Stuttgart (2001), and returned to TUM in 2005. Since 2008, he has also been affiliated with the Dept. of Mechanical Engineering of University of Belgrade, Serbia. Since 2013, Dr. Bungartz has served as Dean of Informatics as well as TUM Graduate Dean, heading TUM Graduate School and being in charge of doctoral education TUM-wide. In both functions, he is a member of TUM's Extended Board of Management.

Dr. Bungartz has served or serves on several editorial boards, and he was a member of the scientific directorate of Leibniz Institute for Informatics Schloss Dagstuhl. Since 2006, he has been chairman of the Commission for IT Infrastructure of the German Research Foundation (DFG). Furthermore, he is involved in various national and international review and advisory board activities. In 2011, he was elected chairman of the German National Research and Educational Network (DFN). Finally, Dr. Bungartz is a board member of Leibniz Supercomputing Centre, one of three national HPC centres.

His research interests are where CSE, scientific computing, and HPC meet. He works on parallel numerical algorithms, hardware-aware numerics, high-dimensional problems, and aspects of HPC software, with fields of application such as CFD. Most of his past and present projects have been interdisciplinary ones. As an example, he coordinates DFG's new Priority Program Software for Exascale Computing.

Dr. Chen Shiyi

Prof. Chen Shiyi graduated from Peking University and got his Ph.D. degree in 1987. From July 1999, Dr. Chen served as the Professor, Department of Mechanical Engineering, Johns Hopkins University (JHU). Now, Prof. Chen Shiyi is the Vice President and Dean of Graduate School at Peking University, China. Prof. Chen Shiyi has published more than 170 scientific papers, edited 3 books and has SCI citations in excess of 10,000 times. Prof. Chen Shiyi was appointed as the secretary-general of the Association of Chinese Graduate Schools in 2011.

Professor Denise Cuthbert

Professor Denise Cuthbert holds a BA (Hons) from the University of Queensland and PhD from the University of Sydney. After holding a range of positions at Monash University, she is currently the Dean of the School of Graduate Research at RMIT University, Melbourne, Australia. She has over 15 years' experience in leadership in Graduate research education in the humanities and social sciences, and now at university level in large university of technology and design. Her work in university leadership and research supervision has been recognized through an Australian national citation (2007) and university awards (2006, 2007). She is an accomplished supervisor with 45 graduates completing under her supervision. Denise has designed innovative programs for the support of graduate research students, particularly in the areas of publishing; and has engaged in policy reform to enable more candidates to complete within time, achieving significant improvements in time to degree, candidate publication counts and overall satisfaction. She has worked in South Africa, Malaysia and Vietnam on research capacity development of staff and institutions and is committed to continuing this work. Her own research and supervision cover a range of humanities and social science disciplines and interdisciplinary fields. Recent research includes an Australian Research Council funded History of Adoption in Australia. Currently Denise's research focus has shifted to higher education policy and practice, including research and research education. Her most recent publications in these fields appear in *Higher Education*, *Studies in Higher Education*, *Higher Education Policy and Management* and *Higher Education Research and Development*.

Dr. Jay Doering

John (Jay) Doering, Ph.D., P.Eng., FCSCE, FEC is Vice-Provost (Graduate Education) and Dean (Faculty of Graduate Studies) at the University of Manitoba, Winnipeg, Manitoba, Canada.

Jay holds a first-class honours B.Sc. in Civil Engineering from Queen's University, Kingston, Ontario, Canada and was the recipient of a Natural Sciences and Engineering Research Council of Canada (NSERC) Centennial Scholarship, which he used to complete a Ph.D. in Coastal Processes at Dalhousie University. He then accepted an NSERC Visiting Fellowship at the National Water Research Institute in Burlington, Ontario, Canada, before starting as a faculty member at McMaster University. In 1993 Jay moved to the University of Manitoba where he rose through the ranks to become Head of Civil Engineering in 2001, Dean of the Faculty of Graduate Studies in July 2005, and Vice-Provost (Graduate Education) and Dean in 2012. He has successfully supervised a significant number of Master's and doctoral students to completion, as well as undergraduate theses. Jay is the Past-President of Western Canadian Deans of Graduate Studies (WCDGS), and the Past-President of the Canadian Association for Graduate Studies (CAGS).

Dr. Noreen Golfman

Noreen Golfman is a professor of English and Dean of Graduate Studies, Provost and Vice President (Academic) pro tempore at Memorial University of Newfoundland. She oversees more than 110 graduate degree programs, many of which are interdisciplinary. Dean Golfman was President of the Canadian Federation for the Humanities and Social Sciences (CFHSS)

for four years. The CFHSS is a lobby that represents over 80,000 Canadian scholars, graduate students and post doctoral fellows. She just completed her term as President of the Northeastern Association of Graduate Schools (NAGS) and is currently President of the Canadian Association of Graduate Schools (CAGS). She is also Chair of the Board of Friends of Canadian Broadcasting, an advocacy organization that serves the interests of the public broadcasting and telecommunications system, and founding director of a popular women's film festival, now celebrating its 25th year. Her scholarship and teaching have long been informed by a strong commitment to public engagement.

In addition to her scholarly contributions on film and literature, Dean Golfman has been writing on the arts in more popular venues, maintaining several weekly columns in newspapers and magazines. She has also been a freelance commentator, reviewer and performer with CBC Radio and Television for over twenty five years. Ever since she was appointed dean she has been writing a weekly blog—*Postcards on the Edge*—largely dedicated to graduate studies concerns. She is an early social media adopter.

Professor Roger Horn

Roger Horn's original training was in physics, with a BSc (Hons) from Monash University in 1971 followed by a PhD from Cambridge University in 1977. He subsequently spent 18 months as a post-doctoral fellow at the Université de Paris Sud, followed by almost ten years at the Australian National University and four years at the US National Institute of Standards and Technology in Gaithersburg, Maryland, before returning to Australia and joining the University of South Australia in 1992. Since graduation, Roger's whole research career has been spent in interdisciplinary areas including physical chemistry, colloid and surface science, biophysics, materials science, tribology, minerals processing, and nanotechnology. His innovative experimental work in these areas has been highly cited. Roger was Deputy Director of the Ian Wark Research Institute at the University of South Australia, with particular responsibility for graduate students, from the time of its foundation in 1994 until 2009 when he took up his current position as Dean of Research Training at Deakin University in Victoria, Australia. There Roger has oversight of university-wide programs and procedures to support graduate research students.

Professor Lucy Johnston

Lucy is Dean of Postgraduate Research and Professor of Psychology at the University of Canterbury, convenor of the NZ Deans and Directors of Graduate Studies (DDOGS) and chair of the Universities NZ Scholarships Committee.

Lucy graduated with a BA (Hons) from the University of Oxford and PhD from the University of Bristol, taught at the University of Cardiff before joining the Psychology Department at Canterbury in 1994. She was on the inaugural management group of the New Zealand Institute of Language, Brain and Behaviour. In 2011 she became Dean of Postgraduate Research.

As Dean Lucy has oversight for all policy and strategy for HDR candidates, skills training for HDR candidates and supervisors. She has been responsible for the introduction of Researchplus to provide doctoral graduates with both generic and disciplinary skills. She developed a course for new thesis supervisors and a series of workshops for experienced supervisors.

Lucy's research expertise, with over 80 international peer-reviewed publications, is in social perception and nonverbal communication. She received a University Teaching Award in 2008 and in 2004 held a Distinguished Visiting Professor position at the University of Connecticut.

Lucy also has an MSc in Sport and Exercise Psychology. She was awarded Oxford Blues and full colours at the University of Bristol for basketball and played on the British Universities. She rowed for her Oxford College and City of Bristol and played soccer for the University of Bristol. She recently retired from 10 seasons completing in road cycling and triathlons.

Dr. Mohan Kankanhalli

Mohan Kankanhalli is the Vice Provost (Graduate Education) at the National University of Singapore (NUS). He is also a Professor of Computer Science at the NUS School of Computing. He was the Associate Provost (Graduate Education) during 2011–2013. Earlier, he was the Vice-Dean for Academic Affairs & Graduate Studies at the NUS School of Computing during 2008–2010 and Vice-Dean for Research during 2001–2007. Mohan obtained his BTech (Electrical Engineering) from the Indian Institute of Technology, Kharagpur, in 1986 and his MS and PhD (Computer and Systems Engineering) from the Rensselaer Polytechnic Institute in 1988 and 1990, respectively.

Mohan's research interests are in Multimedia Systems, Digital Video Processing and Multimedia Surveillance, Security & Privacy. He has made many contributions in the area of multimedia content processing—image & video retrieval, data fusion, visual saliency, computational media aesthetics as well as in multimedia security—multi-camera surveillance, content authentication & privacy. He is actively involved in the Multimedia Systems research community and was the Director of Conferences for ACM SIG Multimedia during 2009–2013. He is on the editorial boards of several journals including the ACM Transactions on Multimedia Computing, Communications, and Applications, Springer Multimedia Systems Journal, Pattern Recognition Journal, and Springer Journal on Big Data.

In July 2012, he was awarded a 5-year S\$10 million research grant by Singapore's National Research Foundation to set up the SeSaMe (Sensor-enhanced Social Media) Centre (<http://sesame.comp.nus.edu.sg>), to do fundamental exploration of the integration of social networks with cyber-physical systems. Mohan is a Fellow of IEEE.

Dr. Barbara A. Knuth

Barbara A. Knuth was appointed Vice Provost and Dean of the Graduate School at Cornell University in 2010. She oversees more than 90 graduate fields that include approximately 1,800 graduate faculty across ten colleges and schools, 5,100 graduate and professional students, and 600 post-docs. She served previously as Senior Associate Dean of the College of Agriculture and Life Sciences at Cornell (2007–2010), and Chair of the Department of Natural Resources (2002–2007). Under Dean Knuth's leadership, the Graduate School offers strong professional development programs focusing on core competencies of leadership, communication, personal development, teaching, and career development, emphasizing transferrable skills relevant to career paths in academia, business, government, and non-profit sectors. Flagship programs focus on writing skills and the creation of writing communities on campus, faculty-led diversity

recruitment efforts, future faculty development, student financial literacy, career development, and data visualization for monitoring student milestones and evaluating and improving student experiences. The Graduate School partners with the Cornell Center for Teaching Excellence, Career Services, and the Knight Institute for Writing in the Disciplines, and is part of the multi-institution Center for the Integration of Research, Teaching, and Learning (CIRTL). Under her leadership, the Graduate School restructured its staff, launched a new web site, improved its information technology, increased its media presence, and expanded its assessment efforts. Knuth served on the Ocean Studies Board of the National Academies and is a past president of the American Fisheries Society. She is Chair-elect of the Council of Graduate Schools Board of Directors.

Dr. Nancy H. Marcus

Dr. Nancy Marcus was appointed Dean of The Florida State University Graduate School in August 2005. She earned a B.A. from Goucher College and a Ph.D. from Yale University. She was a Postdoctoral Scholar and member of the scientific staff at the Woods Hole Oceanographic Institution for 11 years. In 1987 she joined the Department of Oceanography at Florida State University. She served as Director of the FSU Marine Laboratory from 1989–2001, Director of the Women in Math, Science, and Engineering (WIMSE) program from 2001–2005, and Chairperson of the Department of Oceanography from 2003–2005. Dr. Marcus is a Fellow of the American Association for the Advancement of Science, and the Association for Women in Science. She was President of both the American Society of Limnology and Oceanography and the Southern Association of Marine Laboratories. In addition she has served as a member of the Ocean Studies Board of the National Research Council and Chair of the NASULGC Board on Oceans and Atmosphere, and is currently a member of the GRE Advisory Board, the TOEFL Board, and the Board of Directors of the Council of Graduate Schools.

Dr. Liviu Matei

Liviu Matei is the Provost of Central European University (CEU) Budapest and a professor of higher education policy. He also leads the CEU Higher Education Observatory, an initiative promoting applied studies focusing on the relationship between higher education policies and practices and issues of democratic development around the world. Previously, he has taught at universities in Romania, Hungary, and the U.S., served as Director General for International Relations at the Romanian Ministry of Education, consulted on issues of higher education policy for UNESCO, OSCE, the Council of Europe, the Commission of the European Union, for other international inter-governmental and non-governmental organizations, as well as for governmental agencies in several countries. He currently serves on the Board of Trustees of the American University of Central Asia, chairs the European Advisory Board of GRE, is a member of the Advisory Board of the International Higher Education Support Program of the Open Society Foundations, and of the Editorial Board of the Journal of the European Higher Education Area.

Dr. Maureen Terese McCarthy

Maureen Terese McCarthy is Assistant Director of Advancement and Best Practices at the Council of Graduate Schools. She earned her doctorate in English from Emory University in Atlanta in 2013. Since joining CGS full time in June 2013, McCarthy has served as co-PI for the CGS Best Practice project Understanding PhD Career Pathways for Program Improvement, leading efforts to research and write the project white paper. In the CGS Advancement area, she has played a key role in reimagining CGS's corporate partner program, the CGS Sustaining Membership Network. As a CGS Best Practices Intern in 2012, she contributed to several Best Practice projects, including Preparing Future Faculty, the Project for Scholarly Integrity, and Research Ethics Education in Graduate International Collaborations. At that time she served as an editor of the proceedings of the 2011 Strategic Leaders Global Summit on Graduate Education, Global Perspectives on Career Outcomes for Graduate Students: Tracking and Building Pathways.

Professor Mary McNamara

Professor Mary McNamara graduated with an honours degree from the Royal Society of Chemistry and a PhD in Physical Inorganic Chemistry from University College Dublin. As Head of Graduate Research programmes at DIT she administers the academic guidelines and regulations of the Institute in relation to postgraduate research awards. She is the guarantor of graduate research quality assurance and also works with the schools and colleges at DIT in the development of structured PhD programmes. Prof McNamara helps to develop and implement strategies, policies and procedures for growing research in each School and College at DIT. She is also project manager for the recently established interdisciplinary Environmental Health Sciences research institute at the Dublin Institute of Technology which is a unique higher education–business alliance involving Dublin's Metropolitan Authority, the City Council and Ireland's Health Service Executive as partners.

Professor Shireen Motala

Professor Shireen Motala held the position of the Director of the Education Policy Unit, University of the Witwatersrand, from 1999 to February 2010. Her academic qualifications are BA (UDW), B Social Science Honours (UCT), MA (University of Warwick), PGCE (University of London) and PhD (Wits). In March 2010, she was appointed as Director of the Postgraduate Research Centre: Research and Innovation at the University of Johannesburg. Her responsibilities include leading the university wide strategy for improving enrolment at a postgraduate level, providing research support for postgraduate students and ensuring that throughput improves in the institution. She sits on the Board of a number of policy research organisations including the Centre for Education Policy Development and the South African Institution for Distance Education. She was Chairperson of the Education Policy Consortium which brings together policy research entities nationally from 2006 to 2010. She was also the Chairperson of the UNESCO South African Commission from 2002 to 2006. In 2010 she was appointed by the Minister of Higher Education and Training to serve on the Council of Higher Education (CHE) and in 2013 to serve on the Ministerial Task Team to review the national Senior

Certificate examination. She has worked extensively in research and has provided leadership for regional and international partnerships which have led to collaborations with universities across Africa and with northern partners. Her research record is substantial and includes books, editorship of local and international journals and chapters in books. Her research interests and expertise have been in the areas of education financing and school reform, access and equity and education quality.

Dr. Suzanne T. Ortega

Suzanne Ortega became the sixth President of the Council of Graduate Schools on July 1, 2014. Prior to assuming her current position, she served as the University of North Carolina Senior Vice President for Academic Affairs (2011–14). Previous appointments included the Executive Vice President and Provost at the University of New Mexico, and Vice Provost and Graduate Dean at the University of Washington and the University of Missouri. Dr. Ortega's master's and doctoral degrees in sociology were completed at Vanderbilt University.

With primary research interests in mental health epidemiology, health services, and race and ethnic relations, Dr. Ortega is the author or co-author of numerous journal articles, book chapters, and an introductory sociology text, now in its 8th edition. An award winning teacher, Dr. Ortega has also served on a number of review panels for NSF and NIH and has been the principal investigator or co-investigator on grants totaling more than \$6 million in state and federal funds.

Dr. Ortega serves or has served on a number of professional association boards, committees, including, the Executive Boards of the Council of Graduate Schools, the Graduate Record Exam (GRE), the National Academies of Science Committee on the Assessment of the Research Doctorate, the National Science Foundation's Human Resources Expert Panel, the North Carolina E-learning Commission, the North Carolina Public School Forum, the UNC TV Foundation, and the UNC Press Board of Governors.

Professor Laura Poole-Warren

Laura is currently Pro Vice-Chancellor Research Training at The University of New South Wales (UNSW Australia). She is responsible for graduate research strategy and policy, early career researcher matters, as well as for researcher development at the university. Laura is also Professor of Biomedical Engineering and she leads a research group with a focus on bioactive materials and tissue engineering. Her previous appointments include visiting research professor at Rutgers University in the USA, pre-clinical scientist in the biomedical device industry and core biomaterials scientist for the Federal Government Therapeutic Goods Administration expert committee on medical devices. She is also past Chair of the Group of Eight Deans of Graduate Schools and current Convenor of the Australian Council for Deans and Directors of Graduate Research.

Dr. Nirmala Rao

Nirmala Rao is Serena H C Yang Professor in Early Childhood Development and Education, Professor, Faculty of Education and Dean, Graduate School, The University of Hong Kong. A

Developmental and Chartered (Educational) Psychologist by training, she has been recognised internationally for her research on early childhood development and education in Asian cultural contexts. Professor Rao completed her BA at Bangalore University, her MS and PhD at Tulane University, New Orleans and her postdoctoral training in paediatric psychology at Children's Hospital, New Orleans. Professor Rao has published widely and has authored international peer referred journal articles, books, book chapters and research reports. She also serves on the Editorial Board for several journals, is the Associate Editor of *Child Development and Developmental Psychology* and a member of the Steering Committee for the upcoming *Lancet Series on Early Child Development*. Professor Rao is also actively involved in professional organisations that aim to promote the well-being of children through research and advocacy efforts and has been a consultant for UNICEF, UNESCO, and the World Bank. In terms of service to the University, she was Deputy Head of the Departments of Education/Curriculum Studies and Education (1999–2002); Associate Dean, Faculty of Education (2002–2005); Acting Dean of the Faculty of Education (2006–2007); Acting Chairperson of the Board of the Faculty of Education (2008–2009) and Associate Dean, Graduate School (2010–2013). She has been Chairperson of the Board of Graduate Studies since 2010.

Mr. Rafael Sidi

Rafael Sidi is Senior Vice President and General Manager, ProQuest Information Solutions, the business unit focused on developing information solutions to improve researchers' and librarians' outcomes in global academic markets.

Mr. Sidi joined ProQuest in 2013 after a dozen years at Elsevier, where he held several senior positions, including head of product management and development for many of the company's largest, most successful and innovative information solutions. Among the products were ScienceDirect, Engineering Village, illumin8 and Elsevier's first e-book platform, Referex. He also led Elsevier SciVerse efforts to create the first STM online application marketplace and developer network, which opened the ScienceDirect and Scopus platform to third party solutions. His product management roles served customers worldwide in academic, corporate and government markets. Prior to Elsevier, Mr. Sidi was Director of e-commerce operations for Bolt Media Inc., a teen social network platform.

Mr. Sidi holds a BSc in Electrical Engineering from Istanbul's Bosphorus University and an MA from Brandeis University.

Dr. Mark Smith

Mark J. T. Smith received the B.S. degree from MIT and the M.S. and Ph.D. degrees from the Georgia Institute of Technology, all in electrical engineering. He joined the electrical and computer engineering (ECE) faculty at Georgia Tech in 1984, where he remained for the next 18 years. While working primarily on the Atlanta campus, he spent several terms in 1991–93 on the Institute's European campus in Metz, France. Five years later he served a four-year term as Executive Assistant to the President of Georgia Tech. In January, 2003, he joined the faculty at Purdue University as head of the ECE School. A current member of the Board, Smith has been engaged with the national ECE Department Heads Association, where he served as secretary/treasurer, vice president and president in 2005–2008.

In 2009, Smith was appointed Dean of the Purdue University Graduate School. Presently,

he is a member of the Board of Directors and Executive Committee of the Council of Graduate Schools and the GRE Board of Directors.

Dean Smith's scholarly interests are in the area of digital signal processing (DSP). He is a Fellow of the IEEE, and is a former IEEE Distinguished Lecturer. He has authored many technical papers, six international standards publications, three textbooks, and two edited books, the most recent of which is the 2014 edited book GPS for Graduate School-Students Share Their Stories. In addition to his professional activities, Dr. Smith's past includes Olympic competition and U.S. national gold medals in the sport of fencing.

Dr. Zaidatun Tasir

Zaidatun Tasir is a Professor of Educational Technology at the Department of Educational Science, Maths and Creative Multimedia, Faculty of Education, Universiti Teknologi Malaysia. She is also a Dean of School of Graduate Studies, UTM and a research group leader of Creative and Innovative Technology in Education (CITE) under k-Economy research alliance. Prior to that, she was a Deputy Dean (Social Science) of School of Graduate Studies (2009–2010), Deputy Dean (Postgraduate Studies & Research) (2008–2009), Head of Department of Postgraduate Studies (2007–2008), and Information Technology Manager (2004–2007). She obtained her first degree, B. Sc. Comp. with Edu. (Math) (Hons.) from UTM (1995), M. Ed. (Educational Media Computers) from Arizona State University, USA (1998), and Ph.D (Educational Technology) from Universiti Teknologi Malaysia (2002). Her research interests and expertise include Design and Development of Computer and web-based Instructions, Multiple Intelligence through computer-based instruction, Problem-based learning through technology, Social Networking Tools in Education, and Online Social Learning Model.

Dr. Tao Tao

Dean Tao Tao was born in 1964. He obtained both BSc and MSc in Virology from Wuhan University, China. He spent six years in Case Western Reserve University, Cleveland, Ohio from 1995 to 2001 to pursue his Ph.D. majoring in Cell Biology. From 2001 to 2004, he did his post-doctoral fellowship training in McGill University, Canada. He took an independent faculty position in Xiamen University in 2005 and became a tenured professor in 2010. He was vice dean of the graduate school, Xiamen University from 2008 to 2011 and became executive dean in 2012. His papers have been published in prominent journals such as Journal of Cell Biology, Journal of Biological Chemistry, Nuclear Acids Research and Molecular & Cellular Proteomics. As Executive Dean of Xiamen University Graduate School, he has promoted the reform of graduate education in Xiamen University to ensure its quality.

Dr. Wang Jiaping

Wang Jiaping graduated with a bachelor's degree from the department of mechanical engineering at Zhejiang University in 1982, and got a master's degree at the University of Tokyo in 1988, receiving his doctoral degree in engineering at Zhejiang University in 1995.

From 1982 to 2000, he served as lecturer, associate professor, professor, deputy director of production for the engineering institute, head of teaching and research section in the

department of mechanical engineering, vice director of the “211” Project Office in Zhejiang University in 1997, then as the director in 1999.

In 2002, he acted as the director of the development and planning department of Zhejiang University.

From 2008, he served as deputy dean of the graduate school and Director of the Disciplinary Affairs Office. In 2013, he was appointed as executive dean of the graduate school at Zhejiang University.

Dr. Lesley Wilson

Lesley Wilson was educated at the Universities of Glasgow and Strasbourg and also has an honorary doctorate from the Université Pierre et Marie Curie in Paris. She joined the European University Association (EUA) at its creation in 2001 and took over as Secretary General in 2002. In 2008 she was closely involved in establishing EUA’s Council for Doctoral Education (CDE) that supports the development of doctoral education and training in European universities. Prior to joining the EUA she held a number of senior posts in higher education and research management in various European and international organisations including the European Commission, where she was Director of Strategic Planning, Monitoring and Evaluation at the European Training Foundation in Turin (1999–2001), and UNESCO where she was Director of their European Centre for Higher Education, based in Bucharest, from 1995–1999. Before that she was Head of Policy at the European Science Foundation and also contributed to the development of EU education programmes through involvement in the launch phase of ERASMUS and as of 1990 as the Director of the newly established EC TEMPUS Office in Brussels. Her early career was spent in the German Science Council in Cologne. In 2012 Lesley Wilson was awarded the *Ordre national du Mérite* for her services to higher education and research in France.

Dr. James Wimbush

As Dean of the University Graduate School—which oversees academic master’s and doctoral programs on Indiana University’s eight campuses—Dr. James C. Wimbush advocates for the enhancement of graduate education and improvement of the overall quality of graduate student life, and works to increase funding for programs promoting educational equality in science, technology, engineering, and math.

As the Vice President for the Diversity, Equity, and Multicultural Affairs, Wimbush works to create a learning environment that promotes cultural, ethnic, and gender diversity. He also seeks to find meaningful ways to improve the performance of all campuses in retaining, educating, and graduating students, especially those from underrepresented and diverse populations.

Nationally, he works to advance graduate education by serving as the Chair of the Council of Graduate Schools’ Board of Directors; and, as a member of the Executive Committee of the AAU’s Association of Graduate Schools.

A Professor of Business Administration, Wimbush has received multiple awards for his teaching of management and leadership, and formerly chaired various units in the Indiana University Kelley School of Business, including the Department of Management and Entrepreneurship; Doctoral Programs; and the MBA Program.

An acknowledged national authority, he has published numerous articles on business ethics in human resource practices. Wimbush earned a doctorate in management and a master's degree in human resources management and industrial and labor relations from Virginia Polytechnic Institute and State University in Blacksburg, Virginia.

Dr. Lisa Young

Lisa Young is Vice Provost and Dean of Graduate Studies at the University of Calgary and a member of the Board of Directors of the Canadian Association of Graduate Studies. She has been involved in graduate education through much of her career, serving as both a Graduate Program Director and an Associate Dean before being appointed Vice Provost and Dean in 2012. Young holds a PhD in Political Science from the University of Toronto, and has been a member of the University of Calgary Political Science department since 1997, where she is a Professor. She has published extensively in the field of Canadian politics, with a focus on political party organization, election finance and women's participation in public life.



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