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SCIENTIFIC AMBIDEXTERITY AND DOCTORAL MENTORING: DOES ACADEMICS' INVOLVEMENT IN COMMERCIAL SCIENCE INFLUENCE MENTORING IN EAST-ASIAN PROGRAMS?

A Thesis

by

MARIA DEL ROSARIO BENAVIDES

Submitted to Texas A&M International University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

December 2014

Major Subject: Sociology

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Approved as to style and content by:

Chair of Committee,	Marcus Antonius Ynalvez
Committee Members,	John Collins Kilburn, Jr.
	Peter Fuseini Haruna
Head of Department,	Claudia Edith San Miguel

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DEDICATION

Aaron Michael, my beautiful son:

You have enriched my life beyond measure. You are my inspiration and my most precious possession, being your mom is my greatest reward. I thank God for you every day. I love you with all my heart.

ABSTRACT

Scientific Ambidexterity and Doctoral Mentoring:
Does Academics' Involvement in Commercial Science Influence
Mentoring in East-Asian Programs? (December 2014)

Maria Del Rosario Benavides, B. S., Texas A&M International University;

Chair of Committee: Dr. Marcus Antonius Ynalvez

This thesis is in the area of sociology of science. It carries the legacy of Robert K. Merton by addressing two concepts -- scientific ambidexterity (SA) and doctoral science mentoring -- germane to the knowledge production process that are increasingly manifested in contemporary academic science. In regards to SA, I focus on two axes of activities that academics are increasingly expected to engage in and balance: the axis of research collaboration, and of techno-scientific productivity. Each axis represents the tension between the demands of academic science and that of commercial science as experienced by academics. To advance understanding of SA's impact on the socialization of future scientists to scientific life, I examine the relationship between academics' top journal publication and patent generation, and their involvement in academic and in commercial research collaborations on the one hand; and academics' interactions, mentoring practices, and the research experience they provide their doctoral students, on the other hand. I test the hypothesis that ambidextrous academics differ from their non-ambidextrous counterparts in terms of mentor-mentee interaction, mentoring practices, and the research experience they provide their doctoral students. I used survey data collected in summer 2013 from 105 chemical scientists in Japan, Singapore, and Taiwan. I utilized principal component analysis for data reduction, and performed normal error regression analysis to examine relationships between my independent and dependent variables. My results indicated that SA is linked to doctoral mentoring, but not to the extent that every axis of SA shapes every aspect of doctoral mentoring. Between SA in research collaboration and SA in techno-scientific productivity, the former has more to do with mentor-mentee interaction, with mentoring practices, and with research experience than the latter. In other words, between the collaborative and the productivity axes of SA, it is axis of collaboration that has greater impact on doctoral mentoring. My results have important implications for international science training policy.

ACKNOWLEDGEMENTS

The experience of research has stretched me and helped me grow in so many ways. It is only through God's grace and the people He put in my life that this thesis became a reality. There are so many people who helped me to whom I owe my appreciation and gratitude.

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I am proud to been part of a collaborative international research project between sister universities Texas A&M International University and Tamkang University. I offer special thanks to Tamkang University students, faculty and administrators who helped with this project. In particular Xie xie, Lin, Kai -Chun (Lance) Chiu, Huai-Yao (Melanie), Weng, Ying-Ting (Isabel), Liu, Wei-Lien (Olivia), Lin, Cing-Yue (Vito), Lin, Yu-Min (Kim), Chang, Wei-Hsin (Shinny), Gozalan, Celal, department assistant Huang and Yu-Shan (Susan). You are all awesome!

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Finally, my deepest gratitude to my companion, my loyal friends, my sponsors, and spiritual mentors: your words of wisdom inspire me, your lives bless me, and your loyalty humbles me.

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INTRODUCTION

The increasing interaction between academia, industry, and government has brought changes in the knowledge production process. For instance, the Bayh-Dole Act amended in 1980 was developed by Congress in order to respond to economic stagnation and low productivity. Key change for academia was ownership of inventions with federal funding (Thursby and Thursby, 2011). Later, the 2007 America COMPETES Act and its reauthorization of 2010, responded to concerns of economic competitiveness and development in the United States (Public Law, 2007). COMPETES encourages innovation by supporting research and development while expanding programs in areas of national need such as Science, Technology, Engineering and Mathematics (STEM) by sanctioning the National Science Foundation (NSF) authority to award grants towards increasing research improvements for STEM education programs in order to produce a highly skilled workforce that will fuel innovation and high level research (Public Law, 2007). Three practices among academic science identified to potentially promote innovation are university-industry research centers, university patenting, and biotech entrepreneurship, consequently creating academia an economic engine (Berman, 2012). At present, academics are increasingly expected to participate in commercial science activities. Thus, it is pertinent to investigate whether changes in the knowledge production process affect the way academics train doctoral students. I investigate this issue by introducing the concept of scientific ambidexterity (SA). I define SA as balancing *academic research engagement, and the generation of publications and of patents simultaneously*.

This thesis follows the style of *Research Policy*.

In other words, I focus on two axes of activities -- the axis of research collaboration, and of techno-scientific productivity. Each axis represents the tension between the demands of academic science and that of commercial science as experienced by academics. To advance understanding of SA's impact on the socialization of future scientists to scientific life, I examine the relationship between academics' top publication and patent generation, and their involvement in academic and in commercial research collaborations in the one hand; and their interactions, practices, and experiences with their doctoral students, on the other hand.

Statement of the problem

Under the present scenario of: (i) the on-going debates on how to best optimize strategies toward an efficient national innovation system, and (ii) the increasing pressure from contemporary international science policy for scientists in the various strands of the Triple Helix (i.e., academia, government, and industry) to work together towards: (i) the resolution of global issues and problems, (ii) the optimization of returns on investments from scientific research, and (iii) the generation of creativity and innovation, it is important to understand how the growing trend of academics to engage in cross-sectoral activities impact the intrinsic dynamics within each of these sectors (Etzkowitz and Leydesdorff, 2000).

In the case of academic science, which is tasked to pursue curiosity-driven research and, at the same time, train future scientists (or knowledge producers), there is a need to assess and evaluate how the training and the mentoring role of academics are impacted by the increasing pressure to engage in cross-sectoral activities, pursue extrinsic rewards, and adopt new values. Shibayama et al. (2012) and Shibayama and Baba (2011) report that academics are steadily shying away from sharing knowledge and publishing research findings and gravitating toward keeping knowledge and patenting ideas and products as a consequence of close collaborative engagement with scientists in the commercial domain such as corporations and corporate R&D laboratories.

Although Thursby and Thursby (2011) report no negative effect of patent production on academics' publication behavior, there is a strong sense among members of the scientific community that industry's close ties with universities threaten the production of public knowledge (Nature, 2001; Tijssen 2004). With this emerging dynamics among the strands of the Triple-Helix, I argue that there may be impacts on other activities of academic scientists; activities such as mentoring, teaching and training doctoral students. Indeed, I ask the question: Might this same observed secretive attitude and covert behavior have consequences on how the academic scientific community trains future scientists? And if so, how do these external engagements morph the very nature of social interaction between mentors (professors) and their mentees (doctoral students)? This is an important and critical question to pursue as there is a paucity of studies that runs along this important line of inquiry.

Objective of the study

In this study, my objective is to explore and report on the relationship between academics' production of top journal publications and generation of patents, and their involvement in academic and in commercial research collaborations in the one hand; and their interactions with doctoral students, mentoring practices, and provisions provide research experiences to their doctoral students, on the other hand. Toward this end, I adduce data from a sample of chemical science professors in selected elite universities in the East Asian region, whom were interviewed -- face-to-face -- at the actual sites of action and interaction [i.e., the scientific laboratory (Ynalvez et al., 2014)] in the summer of 2013. With this objective in mind, I set on providing answers to the following research question: Does scientific ambidexterity among academics impact how they mentor future scientists? More specifically, does academics' involvement in commercial-science activities alter aspects of their doctoral mentoring? My central hypothesis is: *ambidextrous academics differ from their non-ambidextrous counterparts in terms of mentor-mentee interaction, mentoring practices, and the research experience that they provide their doctoral students*.

Significance of the study

A number of studies have already delved into the impact of inter-relationships on (i) scientific productivity, and (ii) sharing behavior of scientists, but not on their doctoral mentoring --- and *the socialization of future scientists.* Hence, the results of this study have the potential to advance the knowledge base on how the cross-sectoral engagements of academic scientists impact the training of future scientists. Specifically, it will expand our knowledge base on how the commercial engagement of academic scientists shapes how they pass on their knowledge and skills to future generations of scientists. The results of this study will also enlighten the academic scientific community as to how we should proceed in recruiting and retaining the scientist it trains as well as revising our advanced scientific training practices and structures given the evolving nature and dynamics of contemporary science.

REVIEW OF RELEVANT LITERATURE

Scientific ambidexterity

The concept of *ambidexterity* has steadily gained salience in business, management, organizational studies, and even in other fields (Gibson and Birkinshaw, 2004; Nosella et al., 2012). The consistently recurring theme in these studies is that successful organizations are ambidextrous (Gibson and Birkinshaw, 2004). However, with the many studies that populate the literature and with these same studies coming from a variety of literature streams, the concept has taken multiple definitions and forms (Nosella et al., 2012; Raisch and Birkinshaw, 2008). Amidst this apparent confusion in the conceptualization of ambidexterity, Nosella et al. (2012) argues that majority of these studies point to the consensus sentiment that ambidexterity is an organizational capability that makes it possible to resolve different tensions that arise within an organization. Describing ambidexterity as an organizational capability, however, does not necessarily mean that the level of analysis and the unit of analysis are necessarily at the organizational (or meso-level). In fact, Raisch and Birkinshaw (2008) and Nosella et al. (2012) contend that research on the topical area of organizational ambidexterity should specifically identify whether ambidexterity is a capability that exists at the meso-level, the micro-level, or both. In other words, is ambidexterity an inherent attribute of the organization, the individual, or both?

In the development of the notion of ambidexterity, Duncan (1976) casted ambidexterity at the organizational level, and in terms of organizational structure. Duncan argues that organizations attempt to balance among competing demands by putting in place “dual structures” in a manner that some organizational units focus on alignment, while other units focus on adaptation (Gibson and Birkinshaw, 2004). The ability of organizations to balance competing demands through the placement of these dual structures successfully is what Gibson and Birkinshaw (2004) referred to as *structural ambidexterity*. Although acknowledging that ambidexterity is an organizational level capability or attribute, Gibson and Birkinshaw (2004) argue that processes and systems -- not structures -- play an important role in the successful realization of balance among competing demands and tensions that confront organizations. Equipped with the insight that focuses on organizational dynamic processes than static structures, Gibson and Birkinshaw (2004) developed and introduced the concept of *contextual ambidexterity*.

While most major works on organizational ambidexterity (structural and contextual) focus on commercial organizations and the organizational level itself, the work of Ambos et al. (2008) in particular introduced new insights by applying the concept of ambidexterity in the context of academic knowledge production and in the case of academic scientists. By doing so, Ambos et al. (2008) opened the way toward the application of the concept of organizational ambidexterity in the context of academic science, which has a very different set of demands, norms, tensions, and values compared to commercial and/or industrial organizations in general and commercial science in particular. By examining the tensions and the balancing acts that academic knowledge producers contend with and engage in, Ambos et al. (2008) also paved the way toward the casting and applying the concept of ambidexterity to the micro-level of analysis (i.e., social interactions) and micro-level unit of analysis (i.e., the individual).

Inspired by ideas and insights from prior research work on organizational ambidexterity, I introduce the concept of *scientific ambidexterity*. In keeping with Nosella et al. (2012) and with

Chang et al. (2009), I construe *scientific ambidexterity* as a behavioral capability -- not of the organization -- but of the individual to make it possible to resolve multiple tensions and to balance competing demands successfully in the context of scientific knowledge production and in the case of knowledge producers. I frame all these within the context of the increasing expectation from knowledge producers in each of the strands of the Triple Helix (Etzkowitz and Leydesdorff, 2000) to interact, produce, and work together. Consistent with Chang et al. (2009), the notion of scientific ambidexterity incorporates multiple balancing acts along the axes of collaboration, communication, productivity, and professional networking. As a result, I cast the notion of scientific ambidexterity along two core activities (research collaboration and scientific productivity) that require balancing between two seemingly opposed engagements casted along two continuums: (i) commercial research collaboration versus academic research collaboration, (ii) top-journal publication versus patent generation (Ambos et al., 2008).

Doctoral mentoring

Doctoral mentoring has been utilized widely in business and in medicine, mainly as a strategy to increase the success rate of graduates entering a profession (Barker, 2006; Eby et al., 2013; Wright-Harp and Cole, 2008). In comparison, its adoption in training of future scientists has been fairly recent. Not only is doctoral mentoring understudied in the area of academic mentoring but also in science education (Wright-Harp and Cole, 2008). Doctoral mentoring is a social relationship that involves activities, interactions, practices, and routines critical to doctoral students' socialization to a scientific discipline (Delamont and Atkinson, 2001; Kram, 1985; Warwick and Kaiser, 2005). Although there are such things as mentoring networks, doctoral mentoring is typically construed to be a dyadic relationship between a senior, more experienced member (i.e., doctoral mentor/professor) and a junior, less experienced member (i.e., doctoral mentee/student). It is aimed at promoting and enhancing the latter's personal growth and professional development through one-on-one coaching, guidance, and support (Eby et al., 2013; Gattis 2008; Hall and Burns, 2009; Kram, 1985, Ensher et al., 2001). Through close interaction between mentor and mentee, the former transfers the needed information, knowledge, skills, feedback, and encouragement to the latter. There are several aspects of doctoral mentoring critical to a successful relationship: personal attributes of mentor and of mentee, mentor-mentee interaction, and mentoring practices, doctoral research experiences to mention a few (Eby et al., 2013; Foote and Solem, 2009; Ynalvez and Shrum, 2011).

Previous studies have indicated that doctoral students who report having mentoring support: (i) make more timely progress toward their degree, (ii) are more self-confident, and report higher levels of research productivity than do students without a mentor (Campbell, 2003; Darwin and Palmer, 2009; Eby et al,. 2013; Gattis, 2008). On the other hand, negative outcomes were reported by mentees who report poor mentoring support (Eby et al., 2004). In other words, it is not sufficient to have a mentor and to be in a mentoring relationship. It is equally important that the relationship is a supportive one. These findings underscore the fact that mentoring can have positive and negative outcomes which then opens the possibility of identifying best practices.

Mentoring is never culture-free (Williams, 2009). It is shaped and influenced by the larger socio-cultural context, and other environmental arrangements that can influence mentors and mentees, and can either constrain or facilitate their interaction. For example, the idea of who is a good mentor/mentee, or what makes a good mentor/mentee might be all socio-culturally configured. Hence, it is imperative for researchers to adjust and evaluate preconceived concepts, definitions, ideas of mentoring to account for socio-cultural differences; and to be aware of their own cultural biases in “making sense” of their data (Chan, 2008; Williams, 2009).

Research pertaining to academic mentoring is scarce. Even more scare are studies pertaining to aspects of doctoral mentoring. The latest meta-analysis and comprehensive literature review (see Eby et al., 2013) on mentoring highlight the following: (i) the need for more studies on academic mentoring especially in the domain of doctoral science, (ii) the need to have more studies and cases from other social contexts, (iii) the need to delve into the consequences of mentoring on outcomes such as knowledge sharing and scientific productivity (Ynalvez et al., 2013). Clearly, doctoral mentoring is important in acquiring tacit scientific and technical skills acquisition, and to increasing retention and graduation rates. What is not clear is: which aspects of doctoral mentoring -- attributes of mentee and of mentor, of mentoring dyads, attributes of mentor-mentee interaction, mentoring practices, and research experiences -- enable or disable the acquisition and transmission tacit skills in science?

CONCEPTUAL FRAMEWORK

My conceptual framework brings to the fore two main concepts that are germane to the sociology of science and that are increasingly manifested in contemporary academic science. These are the concepts of scientific ambidexterity (SA) and doctoral science mentoring (DSM) (Figure 1). Based on my synthesis of the scholarly work on organizational ambidexterity, I focus on two axes of activities that contemporary academics are increasingly expected to engage in and balance: (i) the axis of research collaboration, and (ii) the axis of techno-scientific productivity. Each of these axes represents the tension between the demands of academic science and the demands of commercial science as experienced by academics.

With the heightened expectation for academics to engage in commercial science activities, they are now confronted with the task of engaging and balancing between collaborating within academia (within sector research collaboration such as interdisciplinary and multidisciplinary collaborations) and collaborating with counterparts in industry (cross-sector research collaboration). Academics are also confronted with the task of engaging and balancing their productivity in terms of output valued in academia (i.e., peer-reviewed publications) and those valued in industry (i.e., patents).

However, these dual axes that academics are expected to engage in and to balance have impact on the very intrinsic activities that academics are expected to perform (Ambos et. al., 2008; Perkmann et al., 2013). One of these activities is the transmission of scientific knowledge, and of technical and social skills to doctoral students; in other words, the one activity pertaining to the doctoral mentoring role of academics. In my conceptual framework, I associate these conflicts, tensions, and trade-offs in academics’ attempt to engage and to balance performances along the axis of productivity and the axis of collaboration with changes in the ways academics interact, mentor, and provide research experience to their doctoral students.

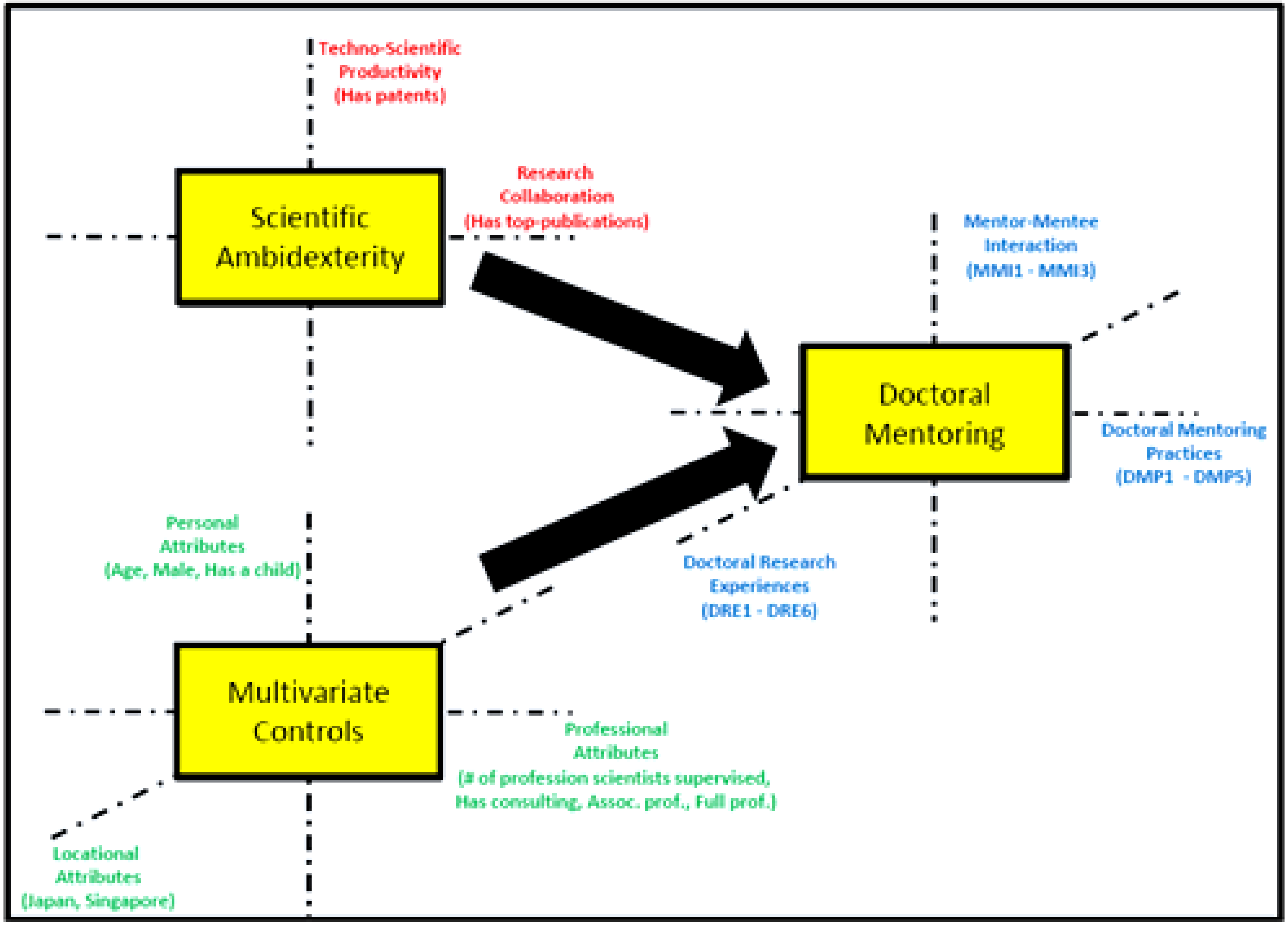

Figure 1. Conceptual framework relating scientific ambidexterity and doctoral mentoring

METHODS

Study locations

This study stems from a larger project aimed to examine the transmission of tacit scientific skills in East Asian graduate science programs. Data for this study contain information on how academics mentor and train doctoral students (i.e., mentor-mentee interaction, doctoral mentoring practices, and doctoral research experiences) at research universities in three East Asian countries (i.e., Japan, Singapore, and Taiwan). Aside from the outstanding performance of these countries in terms of scientific output and technical innovation, and heavy investment in research and development (National Science Board, 2014), these countries were also selected because of the strong professional network ties and past successful research projects with collaborators in these countries.

We chose to engage in this collaborative and multi-disciplinary study (a team of life chemical science professors and sociology professors) in order to gain access to and insights about our study locations and target populations with the intention of better understanding the training of future scientist in the increasingly innovative doctoral programs of the East Asian region. Moreover, we studied universities in these countries because they have shown rapid growth in technical innovation scientific research, and advance science education (Huang and Tan, 2010; National Science Board, 2014). In its 2007 report, the President’s Council of Advisors on Science and Technology (PCAST) details Japan, Singapore and Taiwan to be among the three strongest countries. It is no wonder that East Asian nations’ higher education, science, technology, and research systems are some of the most powerful engines for the region's economic growth (Choi and Nieminen, 2013).

Japan.

Traditionally, Japan has been the scientific leader of Asia. The 1995 Science and Technology Basic Act set in motion the first reconstruction wave of research and development (R&D) in Japan. An allocation of 17 trillion yen allowed for 10,000 postdoctoral researchers to focus on promoting collaborations between government, academia and industry. The second plan allocated 24 trillion yen which focused on life sciences, information and communication, nanotechnology and materials and the environment (Adams et al., 2010). To date, Japan has established dominant positions and commercial forces in electronics, electro-mechanical design and manufacturing, advanced technology development, computer components and office machinery. An example is the Japanese Earth Simulator, a supercomputer designed to predict the behavior of the Earth (PCAST, 2007).

It is also important to note that Japan has one of the best patent systems in the world. According to a 2014 NSF *Science and Engineering Indicator Report*, triadic patents give inventors a simultaneous patent protection, specifically in three of the largest global markets – the European Union, Japan, and the United States. Such patents are expected to have high commercial value. In their 2014 report, the number of triadic patents for the year 2010 was at about 49,000. Another key driver for Japan's strong economy is electrical companies. Japan has ten private electrical companies which include the biggest private utility in the world, Tokyo Electric Power Corporation and the Kansai Electrical Power Corporation, being the second biggest private utility.

Japan is among the top three countries with the most aggressive and largest nuclear energy generation. The United States leads with 104, France follows with 59, and Japan has 55 (IAEA, 2012). In regards to education, both Japan and the United States are among the world's largest providers in education services (National Science Board, 2014). It is no surprise Japanese universities have been known to be major players in global science and high-tech scientific infrastructure (Ynalvez et al., 2014). According to Marginson (2011), and Choi and Nieminen (2013), Japan like Taiwan shares a common Confucian cultural background.

Singapore.

Singapore has successfully maintained economic leadership among Asian economies (Schwab, 2011). Its quality and efficiency in the labor and financial market has positioned it in 2nd place in the world. Singapore is known for its world-class infrastructure and modern architecture. It ranks 3rd in terms of air transport facilities and excellent roads and ports (Adams et al., 2010). Besides being home to two of the top universities in the world, Singapore has many specialized research institutes with the Agency for Science, Technology, and Research (A*STAR) having approximately 10,000 academic researchers in science, technology, and medicine.

Many commercial-based researches are collaborative engagements with transnational or multinational corporations in the areas of nanotechnology, semi-conductors, biotechnology and pharmaceuticals. Singapore has drawn much attention by focusing on quality education. Top universities and high-tech research-oriented educational institutions such as Nanyang Technological University, National University of Singapore, and the Agency for Science, Technology and Research (A*STAR) currently attract and recruit high-caliber scientists from around the world (e.g., Australia, China, India, Japan, and the United States) to their life science research facilities (Normile, 2011; Aguilar et al., 2013). A very unique way to enhance competiveness and to attract elite professors and scientist is through start-up funding provided to assist with research productivity. Although Singapore's top research universities aggressively recruits international talents in Asia and beyond, it also encourages its own young and vibrant professionals to take on scientific and research leadership roles (Huang and Tan, 2010; Ynalvez et al., 2014). Similar to Taiwan and in contrast to Japan, Singapore's universities attracts a flow of international students (Aguilar et al., 2013; Ynalvez et al., 2014). Singapore's ongoing efforts to maintain its competitive edge and the quality of its education are carried out through training and mentoring students in English and by having these students participate in programs with top universities in the United States. Indeed, Singapore has the resources and the right mix of competiveness and dynamism to produce higher levels of techno- scientific research productivity.

Taiwan.

Taiwan is known for being a high-tech powerhouse because of its innovative research in space technology, disaster prevention, nano-electronics, and information technology and biotechnology research. A robust and major factor towards Taiwan's growing patent production and upward technology trajectory are the passage of the Fundamental Science and Technology Act (FSTA). FSTA was inspired by the U.S. Bayh-Dole Act and was legislated in 1999. It authorized the awarding of intellectual property rights to academic researchers, giving universities the right to patent their inventions and thus encouraging commercialization of academic science output and products (Hsu and Yuan, 2013).

According to the 2011-2012 World's Economic Forum Global Competiveness Report, Taiwan ranks 1st in sub-index of new utility patents per million people, and 5th in availability of scientists and engineers. In the context of knowledge production, Taiwan ranked 16th worldwide in terms of producing scientific papers, and number of papers published in journals tracked by Thomson Reuters' Science Citation Index. Undeniably, Taiwan has an excellent educational system, approaching the levels of that of the Japan and the United States (Hara et al., 2010), which is distinguished, at all levels, by high enrollment rates and quality; hence ranking them 10th in higher education and scientific training in the world. Taiwan's researchers are predominantly local, who have earned their doctorates in U.S universities. Like their professors, doctoral students are also predominantly locals with a few students coming from China, India, Indonesia, and the Philippines.

A 2010 United States National Science Foundation (NSF) report indicated that the increasing transnational university partnerships of doctoral programs are becoming a global trend. Hence, developing countries are losing doctoral students to more developed countries through a process of "brain drain". Based on our own empirical observation, the flow of international students from non-English speaking countries was evident in Taiwan universities. It is no wonder Taiwan has a rapidly growing population of scientists and researchers (Kirp, 2010). While Singaporean and Japanese universities train their students in English and in Japanese, respectively; Taiwanese universities take a middle ground approach by using both Mandarin Chinese and English (Aguilar et al., 2013). Elite East Asian universities such as those we surveyed have strong ties with the United States by way of exchange programs, online courses, and web-based lectures (Altback and Knight, 2007; Choi and Nieminen, 2013). Similar to Japan, Taiwan also has a Confucian-oriented culture which put heavy emphasis on family and education (Choi and Nieminen, 2013).

Sampling scheme and data collection technique

In summer 2013, we conducted face-to-face interviews with a sample of chemical scientists (academics/professors) from selected doctoral granting institutions in Japan (n=35), Singapore (n=35), and Taiwan (n=35). In each country, access and permission to chemistry departments, professors and their research laboratories were obtained by our local country coordinator (Aguilar et al., 2013; Ynalvez et al., 2014). A sample of academics (full-time professors) was obtained from rosters generated from each of the selected universities' departmental websites within the targeted institutions. Each interview lasted approximately 1½ hours and was recorded using a digital recorder. In all three countries, majority of the interviews were conducted in English, except in Taiwan where majority of interviews were conducted in Chinese. Our surveys and laboratory observations lasted for approximately a month. Our IRB-approved survey questionnaire included questions about socio-demographic attributes, time-use, laboratory practices, mentoring practices, research involvement, collaborative projects, professional networks, and research productivity.

Dependent variables

For the dependent variables, I focused on *three sets of principal components (PCs)*: the first set was derived from the eight original items that comprised our mentor-mentee interaction (MMI) items. Each item was in the format of a semantic differential scale ranging from -3 to +3

(Neuman, 2011). The second set was derived from the 15 original items that comprised our doctoral mentoring practice (DMP) items. These DMP items specifically focused on the instrumental support function of mentoring rather than the psychosocial support function (Ynalvez et al., 2014). *In regards to these items, we asked respondent academics to think exclusively of their doctoral mentees*.

I derived the third set of PCs from the 17 original items that made up our doctoral research experience (DRE) items. Each of these 32 items -- DMP and DRE items -- was answerable on a 4-point scale, which we defined as follows: 1 = never, 2 = rarely, 3 = often, 4 = very often. In this study, I construe the doctoral research experiences (DRE) provided by professors (academics) to students as shaped by the sets of activities, expectations, and requirements that form the ‘departmental culture.’ Hence, in regards to these items, we asked respondents to think not as a mentor specifically but as a professor in general, and regardless of whether students are his/her mentees or not. With the scarcity of studies that focus on the enculturation of doctoral students to scientific life (Delamont and Atkinson, 2001; Eby et al., 2013), the MMI, DMP, and DRE items we used were derived from available studies, such as those of Delamont and Atkinson (2001), Ynalvez and Shrum (2009), and Ynalvez et al. (2014). I provide the MMI, DMP, and DRE items in Tables 2, 3, and 4.

I conducted a correlation-based principal component (PC) analysis on each of the three sets of items (MMI, DMP, and DRE) and retained PCs that had *eigenvalues* greater than or equal to 1.00 (Field, 2009). As suggested by Field (2009), I used the Anderson-Rubin scoring technique to compute orthogonal scores, which served as dependent variables in our normal error regression analyses. PC analysis is a multivariate statistical technique of finding linear functions of a set of items that preserves most of the information contained in a set of items (Field, 2009;

Quinn and Keough, 2002). My reasons for using PC analysis are the following: (1) to uncover main dimensions that underlie the original 8 MMI, 15 DMP, and 17 DRE items, and (2) to reduce the original number of dependent variables -- 40 in all. That way, we could come up with more tractable sets of regression analyses and results.

Independent variables

Two measures relating to scientific ambidexterity served as our main independent variables: *scientific ambidexterity in research collaboration* (SAColl) and *scientific ambidexterity in scientific productivity* (SAProd), both of which are dummy variables. SAColl = 1 if respondent had a research collaborator in both academia and industry; otherwise SAColl = 0. Similarly, SAProd = 1 if respondent had published in a top journal and had generated patents in the last 2.5 years; otherwise SAProd=0.

Control variables

Respondents' personal and professional attributes comprised the statistical controls in our regression analyses. Nominal level variables were transformed into dummy variables (Field, 2009). Dummy variables were also constructed for gender (male = 1 if male, male =0 if female); for having children (child = 1 if has children, child = 0 if has no children), involved in consulting (consult = 1 if yes, consult = 0 if no), and two dummy variables (associate professor, and full professor) that represented academic rank. Interval-ratio level control variables included mean-centered age (in years), square of mean-centered age (in years squared), and number of professional scientists supervised (Ynalvez and Shrum, 2011)

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Analytical techniques

I performed a series of statistical analyses ranging from a correlation-based principal component (PC) analysis with varimax rotation using the eigenvalue equals one or greater ($\lambda \geq 1$) retention rule (Field, 2009; Quinn and Keough, 2002) to identify the main dimensions (PCs) for MMI, DMP and DRE, to a normal error regression analysis. In labeling these PCs, I considered items that had coefficients greater than or equal to the absolute value of 0.70 (Field, 2009; Ynalvez et al., 2014).

RESULTS AND DISCUSSION

Descriptive statistics

In Table 1, I present descriptive statistics for my control, independent, and dependent variables. Of the 104 chemical science professors we interviewed, 34% were from Japan, another 34% from Singapore, and the remaining 32% from Taiwan. The average age of respondents was about 47 years with a standard deviation of about 10 years. Assuming normal distributions, this would put about 68% of the target population to be within 47 ± 10 years of age. With the strong patriarchal orientation these locations, it was not at all surprising that a large majority (88%) of scientists were male.

The average respondent supervised about 2-3 (2.43 ± 0.63) scientists (visiting scientists and post-doctoral fellows). Forty-three percent reported research consulting activities with industry. This figure is ways higher than that reported by Gray (2011), which was at about 20% for scientists in the U.S. Although this may well be attributed to differences in populations of scientists examined, it would be prudent to delve into the why East Asian scientists have higher rates than U.S. scientists (Gray, 2011). In regards to academic rank, 25% of respondents were assistant professors, 32% associate professors, and 43% full professors.

Research collaboration is one of the important activities in which scientists find themselves engaged in. This is especially true in an era when knowledge production now requires the use of complex equipment and the pooling of talents from multiple disciplines. In Table 1, it is clear that majority of respondents (74%) reported having collaborators in academia. About a third (31%) reported having collaborators in industry, while a quarter

Table 1. Basic statistics.

Variables of the Study	N	Mean	SEM	SD
Japan (1=yes, 0=no)	104	0.34	0.05	0.47
Singapore (1=yes, 0=no)	104	0.34	0.05	0.47
Age (in year)	104	46.94	0.95	9.74
Male (1=yes, 0=no)	104	0.88	0.03	0.33
Has children (1=yes, 0=no)	104	0.75	0.04	0.44
Number of professional scientists supervised	104	2.43	0.60	6.09
Involved in consulting (1=yes, 0=no)	104	0.43	0.05	0.50
Associate professor (1=yes, 0=no)	104	0.32	0.05	0.47
Full professor (1=yes, 0=no)	104	0.43	0.05	0.50
Has collaborators in academics (1=yes;0=no)	104	0.74	0.04	0.44
Has collaborators in industry (1=yes;0=no)	104	0.31	0.05	0.46
Scientifically ambidextrous in collaboration (1=yes; 0=no)	104	0.25	0.04	0.44
Has publications in high impact journals (1=yes; 0=no)	104	0.92	0.03	0.27
Has generated patents (1=yes; 0=no)	104	0.31	0.05	0.46
Scientifically ambidextrous in productivity (1=yes; 0=no)	104	0.30	0.05	0.46

(25%) had collaborators in both academia and industry. From these numbers, it is clear that within sector research collaboration – academics with academics – is still the popular form of cooperative work. In terms of ambidexterity in collaboration (*SAColl*), 25% were ambidextrous while 75% were not. From these numbers, it is clear that academics are still predominantly non-ambidextrous in terms of their collaborative engagement.

With the tightening bond between scientists in academia and in industry, indicators of scientists' productivity now include outputs that are valued in both sectors. In this study, I employed two indicators of techno-scientific productivity to create our measure of *SAProd:* (i) whether respondent had publication in high-impact journals, and (ii) whether respondent had generated any patents. By high-impact, I propose an impact factor of at least a 4.0. In Table 1, it is clear that almost all (92%) respondents had published in high-impact journals over the last 2.5 years, while nearly a third (31%) had generated patents over the same period. Thirty percent of respondents exhibited ambidextrous behavior in terms of productivity. Meaning, they produced both forms of output; output valued in academia (i.e., high-impact journals) and in industry (i.e., patents). Obviously, a large majority of academics still seek productivity in the form of traditional outcomes such as publications in top journal, a finding that is consistent with Thursby and Thursby (2011).

Principal component analysis

The results from the principal component (PC) analyses are presented in Tables 2, 3 and 4. Analysis of the eight original MMI items revealed that three PCs satisfy the Kaiser criterion of eigenvalue greater than or equal to one. The first PC (MMI1) accounted for 23.46% of total variance and is strongly and positively influenced by the items *face-to-face versus technology mediated* (aij = =+0.89), and *frequent versus seldom* (aij=+0.84). Higher MM1 scores translate to a mentor-mentee interaction that can be described as tending toward being technology-mediated (typically email) and limited exchanges and interaction. The second PC (MMI2) accounted for 18.29% of total variation with the items *structured versus unstructured* (aij= +0.77), and *planned versus unplanned* (aij=+0.76) contributing the most to this PC.

With the positive coefficients of these two items, high MMI2 scores translate to a mentor-mentee interaction that tends to be unstructured and unplanned. Professors described this as not having a particular time/day, place, and even an agenda when they meet with students. Students are able to meet with their professors anytime or anywhere. The third PC (MMI3) accounted for 13.14% of total variation and is strongly and positively influenced by the item *general/broad versus specifics/detailed* (aij=+0.71). High MMI3 scores indicate a conversation or discussion about research that gravitates toward details and specifics. On the basis of these results, mentor-mentee interaction can be compactly described along three axes: quality (MMI1), formality (MMI2), and intensity (MMI3) of interaction. All together, these PCs retained 54.89% of total variation in the original 8 MMI items.

Table 2. Principal component analysis of mentor-mentee interaction items.

				MMI PCs		
	Eight Original MMI Items (Semantic Differential)			MMI1 Quality	MMI2 Formality	MMI3 Intensity
1	Face to Face	<---->	Technology-mediated	0.89	-0.07	0.00
2	Formal	<---->	Informal	0.37	0.43	-0.29
3	Frequent	<---->	Seldom	0.84	0.05	-0.07
4	One Way	<---->	Two Way	0.00	0.15	-0.53
5	Quick talks	<---->	Long Discussion	0.06	0.30	0.55
6	Structured	<---->	Unstructured	0.11	0.77	-0.06
7	General/Broad	<---->	Specifics/Detailed	-0.18	0.01	0.71
8	Planned	<---->	Unplanned	-0.19	0.76	0.16
	Eigenvalue			1.88	1.46	1.05
	% of total variance retained			23.46	18.29	13.14

Note: An item (in bold) is considered to heavily influence a PC if its coefficient is greater than or equal to |0.70|.

In Table 3, I present the PC analysis for the original 15 DMP items (*items pertaining to academics' training practices in regards to their mentees*) and I am able to identify five PCs -- DMP1, DMP2, DMP3, DMP4 and DMP5 -- that had eigenvalues greater than or equal 1.0 (Field, 2009). DMP1 retained 23.91% of total variation contained in the original DMP items, is strongly and positively influenced by three items: *mentor helps students draft their CVs* (aij=+0.77), *mentor helps mentees prepare for a job talk/presentation* (aij=+0.72), and *mentor helps mentees* *with job search* (aij=+0.73). I named DMP1 – the practice of helping mentees with job search. Items that strongly correlated with DMP2 were the following: *mentor discusses with mentees their career aspirations and plans* (aij=+0.70), *mentor socializes students to members of the professional community* (aij=+0.73). This component retained 13.52% of total variation and was labeled DMP2 – the practice of socializing mentees to the profession.

I labeled DMP3 – the practice of monitoring the progress of mentees because the items *mentor monitors mentees work progress* (aij=+0.83) and *mentor discusses mentees' concerns and problems about research* (aij=+0.79) heavily influenced this PC, which retained 10.45% of total variation. Only one item strongly influenced DMP4; this was *mentor co-authors research paper or book chapter with mentees* (aij=+0.72). Hence, I named DMP4 – the practice of co-authoring with mentees. This PC retained 8.10% of total variation. Yet another PC -- DMP5 -- had only one item that strongly correlated with it. That item was *mentor analyzes data and performs calculations side-by-side with mentees* (aij=+0.81). I named DMP5 – the practice of analyzing data side-by-side with mentees. This retained 6.71% of total variation.

Using the same analytical template as above, I reduced the 17 DRE items (*items pertaining to academics' practices in training students regardless of whether these are their doctoral mentees or not)* to six PCs: DRE1 to DRE6 (Table 4). Three items heavily contributed to DRE1. These items were *professor have his/her students write papers for submission to scholarly journals* (aij = +0.73), *professor have his/her students draft letters to journal editor for submission of manuscripts* (aij = +0.85), and *professor have his/her students draft responses for revised-and-resubmitted manuscripts* (aij = +0.88). Clearly, the underlying dimension represented by these items points to a practice, which we termed DRE1 – journal publication training.

I observed DRE2 to have strong correlation with: *professor have his/her students write manuals for lab instruments/equipment*, and *professor have his/her senior students help junior students with their research*. As such, I labeled this PC as DRE2 - lab management training. For DRE3, results indicate that the following items had strong influence: *professor have his/her students present at conferences* (aij = + 0.79), *professor have his/her students write and submit grant proposals* (aij = +0.75), and *professor have his/her students preside lab meetings* (aij = +0.72). With these items, I defined this PC as DRE3- leadership training**.**

DRE4 had a sole item defining it. That item was related to *mentors have student review/comment on reports/papers produced by the lab*. For us, this activity meant training students to think analytically and critically. I labeled this PC as DRE4 – training to think critically**.** With single items defining DRE5 and DRE6 – DRE5 defined by the item *professor have his/her students perform data analysis*, and DRE6 by the item *professor have his/her students organize professional meetings/conferences* – I labeled these PCs as DRE5- data analysis training and DRE6 – training on conference organizing.

In summary my PC analyses for the 15 DMP items and the 17 DRE items revealed that these two sets of items can be reduced into five and six main components, respectively, which I later on use as one of the sets of dependent variables in my normal error regression analysis.

Regression analysis

In the previous section, I teased out the PCs that underlie the original MMI, DMP, and DRE items. Using normal error regression analysis, I examined how our control and independent variables configure mentor-mentee interaction (MMI1-MM3; Table 5), doctoral mentoring practices (DMP1-DMP5; Table 6), and doctoral training practices (DRE1-DRE6; Table 7). It is clear from Table 5 that SAProd has no impact on the quality, formality, and specificity of mentor-mentee interaction. Academics' simultaneous pursuit of dual forms of productivity (publications and patents) had neither positive nor negative impact on academics' reported interaction with their doctoral mentees.

This finding is supportive of the assertion from previous studies that academics' involvement in patent production does not diminish their commitment to traditional academic activities such as engaging their doctoral students in discussions (Perkmann et al., 2013; Thursby and Thursby, 2011). However, in the absence of previous studies that specifically examine the impact of SAProd on mentoring, I am unable to say if my findings of no impact reflects a shift from a positive impact to a no impact, which if true should cause for concern.

Although results from Table 5 indicate that ambidexterity in collaboration (SAColl) has no impact on the quality and formality of interaction, SAColl has a positive impact (B=+0.33; p<.01) on the specificity of academics' reported interaction with their mentees. In other words, professors who reported simultaneous involvement in collaborations with counterparts in academia and in industry were also those who reported having detailed discussions and specific research-related conversations with doctoral students. This finding in particular negates the assertion from previous studies that commercial science involvement makes academics less attentive and dedicated to their students (Shibayama et al., 2013).

In general, I find no empirical support for the concern that academics' involvement in commercial science activities may serve to dampen and reduce the quality, formality, intensity of interaction between mentors and mentees (Perkmann et al., 2013). Instead, results from Table 5 appear to partially confirm the hypothesis that scientific ambidexterity impacts mentor-mentee

Table 3. Principal component analysis of doctoral mentoring practices items.

	Fifteen Original DMP Items	DMP PCs				
		DMP1 Help in Job Search	DMP2 Professional Socialization	DMP3 Progress Monitoring	DMP4 Co-authoring	DMP5 Data Analyzing
1	Mentor discusses career aspirations and plans of students	0.31	0.70	0.14	-0.21	-0.10
2	Mentor monitors students work progress	0.02	0.01	0.83	0.08	0.02
3	Mentor discusses students' concerns and problems about research	-0.03	0.10	0.79	0.15	0.25
4	Mentor discusses personal and/or family problems of students	0.53	0.24	0.09	-0.10	0.23
5	Mentor co-authors research paper or book chapter with students	0.08	0.08	0.32	0.72	-0.09
6	Mentor co-directs research projects with students	0.43	-0.06	0.20	0.49	0.00
7	Mentor analyzes data/performs calculations side-by-side with student	0.08	0.01	0.08	0.04	0.81
8	Mentor run experiments side-by-side with students	0.13	-0.03	0.31	-0.49	0.58
9	Mentor reviews students for general/comprehensive exams	0.18	0.18	-0.06	0.61	0.47
10	Mentor helps students draft job application letters	0.50	0.45	-0.28	-0.08	0.00
11	Mentor helps students draft their curriculum vitae	0.77	0.00	-0.18	0.12	0.09
12	Mentor helps students prepare for job-talks or presentations	0.72	0.02	0.04	0.33	-0.04
13	Mentor helps students search for job positions and announcements	0.73	0.28	0.13	0.06	0.05
14	Mentor socializes students to members of the professional communit	0.12	0.73	-0.09	0.40	-0.03
15	Mentor gives feedback on students' research and performance	-0.02	0.63	0.22	0.18	0.41
	Eigenvalue	3.59	2.03	1.57	1.22	1.01
	% of total variance retained	23.91	13.52	10.45	8.10	6.71

Note: An item (in bold) is considered to heavily influence a PC if its coefficient is greater than or equal to |0.70|.

Table 4. Principal component analysis of doctoral research experience items.

	Seventeen Original DRE Items	DRE PCs					
		DRE1 Publication Training	DRE2 Laboratory Mngt Training	DRE3 Leadership Training	DRE4 Critical Analysis Training	DRE5 Data Analysis Training	DRE6 Conference Org. Training
1	Presents research in departmental/laboratory seminars	0.26	0.30	0.05	0.62	0.17	-0.35
2	Presents research at conferences	0.07	0.16	0.79	0.21	0.24	0.02
3	Participates in research competitions	-0.09	-0.27	0.07	0.66	0.13	0.18
4	Attends trainings to enhance research skills and techniques	0.26	0.26	-0.16	0.43	-0.45	0.22
5	Organizes professional meetings conferences	0.18	0.17	0.01	0.14	0.13	0.75
6	Performs data analyses	0.09	0.11	-0.04	0.03	0.81	0.05
7	Writes and submits grant proposals	0.27	0.07	0.75	-0.04	-0.06	0.08
8	Presides or takes the lead in research lab meetings	0.13	0.15	0.72	0.16	-0.10	0.00
9	Comments on manuscripts mentor are reviewing for journals	0.31	-0.05	0.12	-0.09	-0.40	0.56
10	Writes papers for submission to scholarly journals	0.73	0.12	0.28	-0.04	0.21	0.06
11	Drafts letters to the editor for submission of manuscripts	0.85	-0.08	0.04	0.08	-0.09	0.26
12	Drafts responses for revised and resubmitted manuscripts	0.88	0.06	0.20	0.05	-0.06	0.04
13	Visits other laboratories to learn research skills and techniques	0.04	0.70	0.38	-0.08	0.02	0.17
14	Writes operating manuals for lab instruments and equipment	0.18	0.78	0.15	0.11	0.02	-0.10
15	Has senior students help junior students in their research	-0.13	0.84	0.01	0.03	0.09	0.16
16	Reviews/comments on reports and papers produced by the lab	0.00	0.12	0.22	0.70	-0.12	0.07
17	Reviews/critiques recently published leading research articles	0.04	0.37	0.33	0.21	0.43	0.44
	Eigenvalue	4.12	2.154	1.44	1.39	1.21	1.09
	% of total variance retained	24.22	12.67	8.47	8.18	7.09	6.43

Note: An item (in bold) is considered to heavily influence a PC if its coefficient is greater than or equal to |0.70|.

Table 5. Normal error regression analysis of mentor-mentee interactions PCs.

Control and Independent Variables	MMI 1 Quality			MMI 2 Formality		MMI 3 Intensity		
	β		SE	β	SE	β		SE
Japan (1=yes, 0=no)	0.38	**	0.27	0.18	0.31	-0.18		0.29
Singapore (1=yes, 0=no)	0.15		0.33	0.33	0.38	0.11		0.36
Age (yrs; linear term)	0.03		0.02	-0.23	0.02	-0.34		0.02
Age squared (yrs; quadratic term)	-0.12		0.00	0.02	0.00	0.45	***	0.00
Male (1=yes, 0=no)	-0.09		0.28	0.13	0.32	-0.02		0.30
Has children (1=yes, 0=no)	0.09		0.23	-0.03	0.26	0.11		0.24
No. of professional scientists supervised	0.40	***	0.02	-0.02	0.02	-0.09		0.02
Involved in consulting (1=yes, 0=no)	0.18		0.21	0.14	0.24	-0.05		0.23
Associate professor (1=yes, 0=no)	-0.03		0.37	0.19	0.42	0.51	**	0.40
Full professor (1=yes, 0=no)	-0.10		0.50	0.35	0.57	0.43		0.54
Scientifically ambidextrous in collaboration (1=yes; 0=no)	-0.11		0.26	-0.13	0.29	0.33	**	0.28
Scientifically ambidextrous in productivity (1=yes; 0=no)	0.13		0.21	-0.17	0.24	-0.14		0.23
Adjusted R^2 (%)	18.30			-0.80		8.30		

Note: *,**,*** denote significance at the .05, .01, and .001 levels, respectively.

interaction; partial in the sense that not all three PCs of MMI were associated with the two aspects of scientific ambidexterity. Although scientific ambidexterity appeared to have shaped interaction, it is only the aspect pertaining to collaboration (SAColl) however that does so. Yet this shaping of interaction appears not to be in the direction of SAColl having “deleterious” effects.

In regards to DMP, results again indicate that ambidexterity in productivity (SAProd) has no impact on any of the five DMP PCs (Table 6). Simultaneously publishing in top journals and producing patents *does not* impact mentors’ helping mentees with job search, socializing mentees to the profession, advising and monitoring of mentees’ progress, co-authoring with mentees, or analyzing data with mentees. But again, in the absence of previous studies that specifically examine the impact of SAProd on mentoring, we are unable to say if our results were indicative of a shift from a positive impact to a no impact. In regards to collaborative ambidexterity (SAColl), I perceived that this aspect had a positive (B = +0.31; p<.01) influence on DMP but only on the PC that pertained to mentors’ socializing of mentees to the profession.

In other words, chemical science professors involved in research collaborations with scientists in academia and in industry were more likely to socialize and expose their mentees to the profession, and to the aspirations and ideals of the discipline. Between the two aspects of scientific ambidexterity – SAProd and SAColl, being productively ambidextrous appears not to influence academics’ reported mentoring practices. While practically the same thing can be said about being collaboratively ambidextrous, this aspect somehow appears to influence how academics socialize their mentees to the profession.

So why might professors involved in collaborative work with academic and with industry partners be more into socializing mentees to the profession? It could be that professors' involvement in cross-sector research work triggers curiosity among mentees and in turn generate questions as to where they -- mentees -- should be headed for after doctoral school. This cascade of questions may have been directed to professors, which in turn prompted these professors to expose and socialize their mentees to both academic and commercial side of the profession in the hope answering these questions. It could also be the case that ambidexterity commands respect and carries prestige such that it motivates academics to showcase their status by intentionally exposing and socializing their mentees.

In the case of DRE, both SAProd and SAColl influenced at least one PC (Table 7). SAProd exhibited negative impact (B = -0.23; $p<.05$) on the *data analysis training* provided by professors to their students. Meaning, professors who published in top journals and who at the same time produced patents were also those least likely to report having trained students in data analysis. Most academics we interviewed were of the opinion that it was not their job to teach their students how to analyze data. Most opined that students could always consult a statistician for such tasks, or students can learn this on their own.

In the case of productively ambidextrous professors, it could be the case that this opinion is even reinforced given the dual form of output expected of them. In addition, with the existence of data analysis departments or statistics units in both academic and corporate settings, professors might rather have their students focus on research activities other than data analyses.

In regards to SAColl, results indicate that academics who were involved in collaborative research with counterparts in academia and in industry were likely (B = +0.29;

$p<.05$) to expose their students to activities that develop critical thinking skills. Most of the academics we interviewed mentioned that it was the job of the professor to hone student’s critical thinking skills. For professors, learning how to use instruments or operate equipment in the lab or even running experiments should be learned by the students themselves or by seeking help from other students including post-doctoral fellows. It is also possible that collaboratively ambidextrous professors are more into honing the critical thinking skills of their doctoral students because these skills not only needed to be a successful scientist, but are also the same skills needed to successfully navigate the demands of both academic (curiosity-driven) and corporate (profit-driven) science.

Table 6. Normal error regression analyses of doctoral mentoring practices PCs.

Control and Independent Variables	DMP1 Help in Job Search		DMP2 Professional Socialization		DMP3 Progress Monitoring		DMP4 Co-authoring		DMP5 Data Analyzing	
	β	SE	β	SE	β	SE	β	SE	β	SE
Japan (1=yes, 0=no)	-0.18 *	0.29	0.28 *	0.25	0.17	0.27	0.37 **	0.29	-0.02	0.28
Singapore (1=yes, 0=no)	0.11 *	0.37	-0.08	0.33	0.26	0.35	0.57 ***	0.38	0.06	0.36
Age (yrs; linear term)	-0.34	0.02	-0.13	0.02	-0.36 *	0.02	0.21	0.02	0.19	0.02
Age squared (yrs; quadratic term)	0.45	0.00	0.11	0.00	0.23	0.00	-0.08	0.00	0.32 *	0.00
Male (1=yes, 0=no)	-0.02	0.31	-0.06	0.27	0.21 *	0.29	0.07	0.31	0.04	0.30
Has children (1=yes, 0=no)	0.11	0.26	0.16	0.23	0.05	0.24	-0.02	0.26	-0.14	0.25
No. of professional scientists supervised	-0.09	0.02	0.13	0.01	0.03	0.02	0.06	0.02	-0.16	0.02
Involved in consulting (1=yes, 0=no)	-0.05	0.23	0.09	0.20	-0.14	0.22	0.10	0.24	0.09	0.23
Associate professor (1=yes, 0=no)	0.51	0.41	0.12	0.36	0.09	0.39	0.08	0.41	-0.09	0.39
Full professor (1=yes, 0=no)	0.43	0.55	0.11	0.48	0.20	0.52	0.16	0.55	-0.40	0.53
Scientifically ambidextrous in collaboration (1=yes; 0=no)	0.33	0.29	0.31 **	0.26	0.10	0.28	-0.19	0.30	0.01	0.28
Scientifically ambidextrous in productivity (1=yes; 0=no)	-0.14	0.23	-0.16	0.20	-0.08	0.22	-0.03	0.24	-0.11	0.23
Adjusted R^2 (%)	5.20		29.80		11.40		6.00		14.70	

Note: *,**,*** denote significance at the .05, .01, and .001 levels, respectively.

Table 7. Normal error regression analyses of doctoral research experiences PCs.

Control and Independent Variables	DRE1 Publication Training		DRE2 Laboratory Mngt Training		DRE3 Leadership Training		DRE4 Critical Analysis Training		DRE5 Data Analysis Training		DRE6 Conference Org. Training	
	β	SE	β	SE	β	SE	β	SE	β	SE	β	SE
Japan (1=yes, 0=no)	0.16	0.31	0.16	0.30	0.33 **	0.25	-0.20	0.30	0.54 ***	0.27	-0.09	0.30
Singapore (1=yes, 0=no)	0.19	0.40	0.08	0.39	-0.41 **	0.33	0.11	0.39	0.46 **	0.36	-0.23	0.39
Age (yrs; linear term)	0.09	0.02	-0.26	0.02	0.02	0.02	-0.25	0.02	-0.04	0.02	-0.02	0.02
Age squared (yrs; quadratic term)	0.05	0.00	0.08	0.00	0.07	0.00	0.33 *	0.00	0.05	0.00	0.24	0.00
Male (1=yes, 0=no)	0.09	0.33	-0.03	0.32	0.18	0.27	0.06	0.32	-0.05	0.29	-0.04	0.32
Has children (1=yes, 0=no)	-0.07	0.27	0.20	0.26	0.05	0.22	0.01	0.26	-0.10	0.24	-0.08	0.27
No. of professional scientists supervised	0.07	0.02	0.04	0.02	0.09	0.01	0.07	0.02	-0.27 **	0.02	0.10	0.02
Involved in consulting (1=yes, 0=no)	0.06	0.25	0.02	0.24	-0.03	0.20	-0.09	0.24	0.06	0.22	-0.05	0.24
Associate professor (1=yes, 0=no)	0.14	0.45	0.23	0.44	-0.23	0.37	0.46 *	0.44	0.13	0.40	-0.02	0.44
Full professor (1=yes, 0=no)	0.12	0.60	0.49	0.58	-0.40	0.49	0.52	0.58	0.38	0.53	0.02	0.58
Scientifically ambidextrous in collaboration (1=yes; 0=no)	-0.13	0.30	0.03	0.29	0.17	0.24	0.29 *	0.29	-0.08	0.26	0.09	0.29
Scientifically ambidextrous in productivity (1=yes; 0=no)	0.09	0.25	-0.17	0.24	-0.09	0.21	0.07	0.24	-0.23 *	0.22	0.01	0.25
Adjusted R^2 (%)	-6.60		0.10		29.90		3.50		18.30		-0.20	

Note: *,**,*** denote significance at the .05, .01, and .001 levels, respectively.

CONCLUSIONS AND IMPLICATIONS

I introduced a concept that describes a form of scientific engagement -- *a type of balancing act* -- that contemporary knowledge producers find themselves involved in as a result of a fast-emerging and rapidly-growing trend in international science policy that encourages knowledge producers in the different scientific sectors of the Triple Helix (i.e., academia, government, and industry) to work and co-produce together. I introduced the concept of *scientific ambidexterity* (SA) and casted it at the micro-level i.e., the (individual-level). I construe SA as the ability of knowledge producers to juggle the activities (e.g. collaboration and productivity) in at least two scientific sectors simultaneously (Ambos et al., 2008).

Aside from introducing a concept and sketching its conceptual definition, I also explored the proposition that: academics' SA impacts how future knowledge producers (doctoral students) are mentored and trained. I then asked a question. *Does scientific ambidexterity among academics impact how they mentor future scientists?* This question or exploration per se was inspired by the concern that academics' commercial science engagement might take them away from their traditional roles as mentors and teachers. I contend that SA implies a difference between ambidextrous and non-ambidextrous academics in terms of their attitude, behavior, practices, and style in mentoring. I argue that the difference is mainly a result of navigating the terrain, of being exposed to differing reward and value systems, and of meeting the demands of the different scientific sectors simultaneously.

My findings suggest that in order for scientists to be scientifically ambidextrous they need to develop ambidexterity in two spheres: scientific ambidexterity in collaboration (i.e., involvement in academic and in commercial research at the same time; SAColl), and scientific ambidexterity in productivity (i.e., simultaneously publishing in top journals and generating patents; SAProd). On the other hand, I focused on three aspects of doctoral training: (i) mentor-mentee interaction, (ii) mentoring practices, and (iii) research experiences. Overall, my findings indicated that academics' SA shaped doctoral training, but not to the extent that both aspects -- SAColl and SAProd -- influenced each and every aspect of training (i.e., interaction, practices, and experiences). SAColl had more to do than SAProd in shaping interaction, practices, and experiences.

That impact -- the impact of SAColl and SAProd -- took the form of enhanced intensity of interaction, increased professional socialization of mentees by mentors, and heightened emphasis on analytical-critical thinking. More specifically, academics' simultaneous involvement in collaborative research with colleagues in academia and in industry points to the following portrait of mentoring: (i) a mentor-mentee interaction that *is into details and specifics with regards to conversations and discussions about research activities*, (ii) a mentoring practice that *socializes mentees to the profession such as personally introducing mentees to scholars in the field*, and (iii) a research experience that *engages students to analyze and think critically by way of critiquing and reviewing articles, manuscripts, and reports*. All of these seemingly discount the concern that SA (or involvement with industry) might take academics away from their traditional roles. In other word, my findings suggest that mentors opt to work with mentees that i) are well prepared, ii) are critical thinkers and can analyze their own data, and iii) can work independently.

Although I posed a research question and provided a conceptual framework to address the question these conclusions come with the following implications: (i) results should *not* be taken as having established causality between SA and doctoral training. At best, these results are correlational and should be interpreted with caution. (ii) The sample, although random, is small and represents only one side of the training (or mentoring) relationship – the professors'/mentors' point of view. With these weaknesses, results may not have the desired statistical power that would have produced robust results. As a "one-sided rendition" of training (or mentoring) relationship, results are far from a holistic representation of the dynamics of mentoring. I strongly recommend that future studies use large samples, and work on mentoring dyads. (iii) Given that this study is the first to introduce the concept of SA, there is still a lot to be done in terms of refining SA's conceptual and operational definitions, and of examining its antecedents, correlates, and consequences (Eby et al., 2013; Perkmann et al., 2013).

In terms of science policy implications: with the increasingly tightening bond between academic and commercial science -- really among scientists in the *Triple Helix* -- there is a need to review and to rethink how we mentor and train future scientists -- in this case, doctoral science students. That way, students are by no means socialized to thinking that academia is the one and only destination -- *the premium destination* -- for Ph.D. holders; and that appointments and jobs in industry, or in government are equally feasible, respectable, and viable paths to scientific life (Ynalvez et al., 2014). In addition, our results call attention to the need to formulate guidelines, policies, and protocol that would govern inter-sectoral science activities and the training of future scientists.

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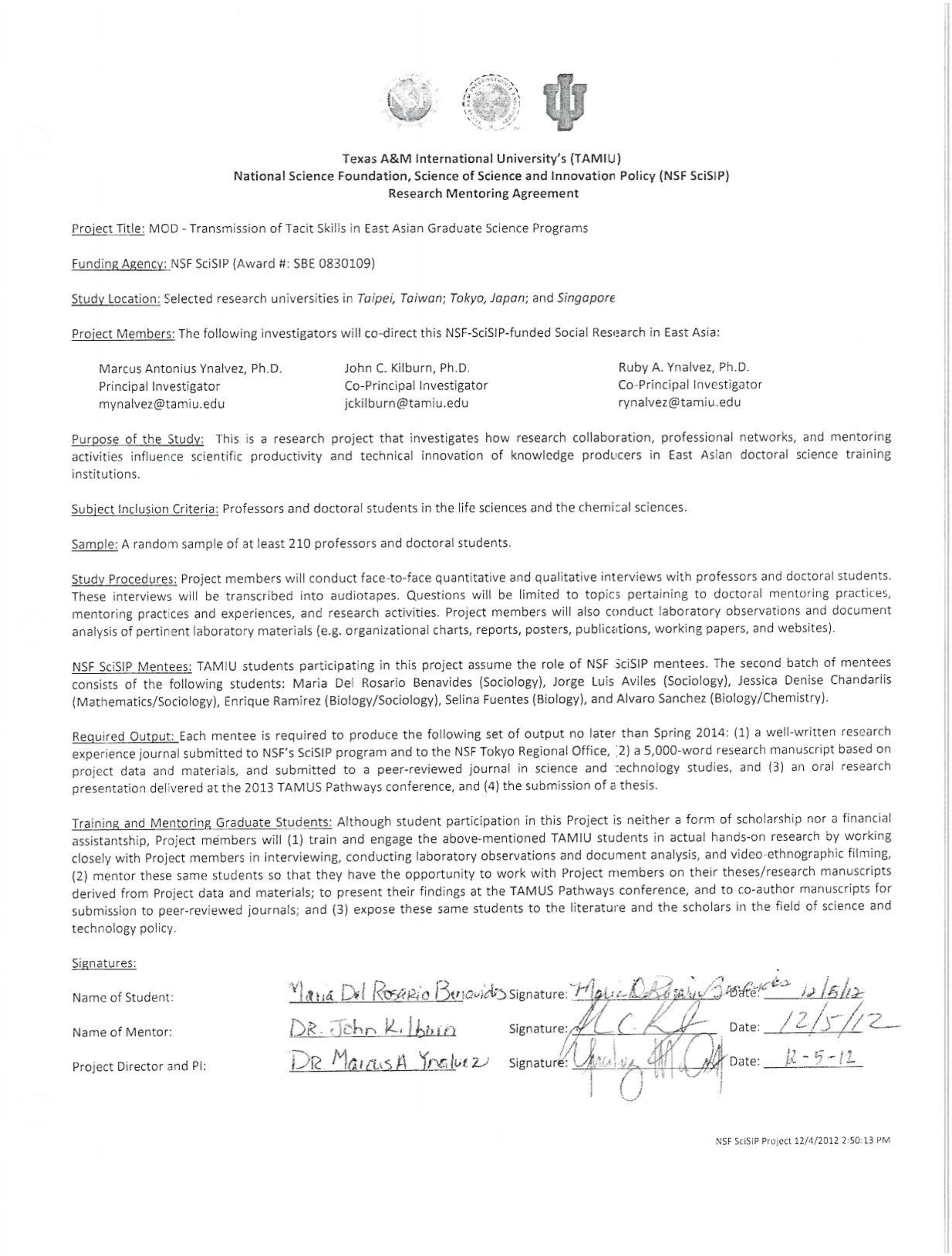
APPENDICES

APPENDIX A

Texas A&M International University's National Science Foundation, Science of Science and Innovation Policy Research Mentoring Agreement



Texas A&M International University's (TAMIU)
National Science Foundation, Science of Science and Innovation Policy (NSF SciSIP)
Research Mentoring Agreement

Project Title: MOD - Transmission of Tacit Skills in East Asian Graduate Science Programs

Funding Agency: NSF SciSIP (Award #: SBE 0830109)

Study Location: Selected research universities in *Taipei, Taiwan*; *Tokyo, Japan*; and *Singapore*

Project Members: The following investigators will co-direct this NSF-SciSIP-funded Social Research in East Asia:

Marcus Antonius Ynalvez, Ph.D. Principal Investigator mynalvez@tamiu.edu	John C. Kilburn, Ph.D. Co-Principal Investigator jckilburn@tamiu.edu	Ruby A. Ynalvez, Ph.D. Co-Principal Investigator rynalvez@tamiu.edu

Purpose of the Study: This is a research project that investigates how research collaboration, professional networks, and mentoring activities influence scientific productivity and technical innovation of knowledge producers in East Asian doctoral science training institutions.

Subject Inclusion Criteria: Professors and doctoral students in the life sciences and the chemical sciences.

Sample: A random sample of at least 210 professors and doctoral students.

Study Procedures: Project members will conduct face-to-face quantitative and qualitative interviews with professors and doctoral students. These interviews will be transcribed into audiotapes. Questions will be limited to topics pertaining to doctoral mentoring practices, mentoring practices and experiences, and research activities. Project members will also conduct laboratory observations and document analysis of pertinent laboratory materials (e.g. organizational charts, reports, posters, publications, working papers, and websites).

NSF SciSIP Mentees: TAMIU students participating in this project assume the role of NSF SciSIP mentees. The second batch of mentees consists of the following students: Maria Del Rosario Benavides (Sociology), Jorge Luis Aviles (Sociology), Jessica Denise Chandarlis (Mathematics/Sociology), Enrique Ramirez (Biology/Sociology), Selina Fuentes (Biology), and Alvaro Sanchez (Biology/Chemistry).

Required Output: Each mentee is required to produce the following set of output no later than Spring 2014: (1) a well-written research experience journal submitted to NSF's SciSIP program and to the NSF Tokyo Regional Office, (2) a 5,000-word research manuscript based on project data and materials, and submitted to a peer-reviewed journal in science and technology studies, and (3) an oral research presentation delivered at the 2013 TAMUS Pathways conference, and (4) the submission of a thesis.

Training and Mentoring Graduate Students: Although student participation in this Project is neither a form of scholarship nor a financial assistantship, Project members will (1) train and engage the above-mentioned TAMIU students in actual hands-on research by working closely with Project members in interviewing, conducting laboratory observations and document analysis, and video-ethnographic filming, (2) mentor these same students so that they have the opportunity to work with Project members on their theses/research manuscripts derived from Project data and materials; to present their findings at the TAMUS Pathways conference, and to co-author manuscripts for submission to peer-reviewed journals; and (3) expose these same students to the literature and the scholars in the field of science and technology policy.

Signatures:

Name of Student:	Maria Del Rosario Benavides	Signature:	Date: 12/5/12
Name of Mentor:	DR. John Kilburn	Signature:	Date: 12/5/12
Project Director and PI:	DR Marcus A Ynalvez	Signature:	Date: 12-5-12

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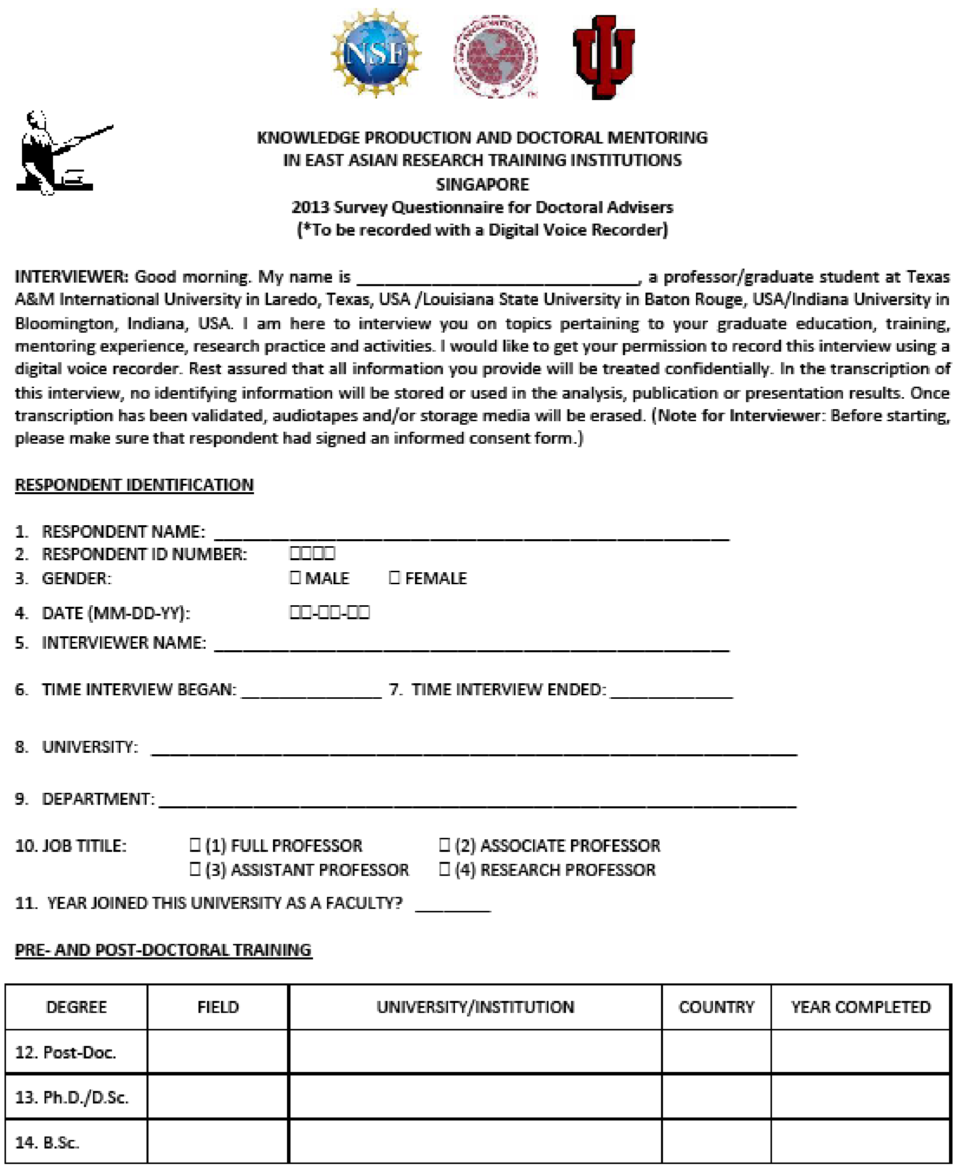
APPENDIX B

Knowledge Production and Doctoral Mentoring in East Asian Research Training Institutions 2013 Survey Questionnaire for Professors



KNOWLEDGE PRODUCTION AND DOCTORAL MENTORING
IN EAST ASIAN RESEARCH TRAINING INSTITUTIONS
SINGAPORE
2013 Survey Questionnaire for Doctoral Advisers
(*To be recorded with a Digital Voice Recorder)

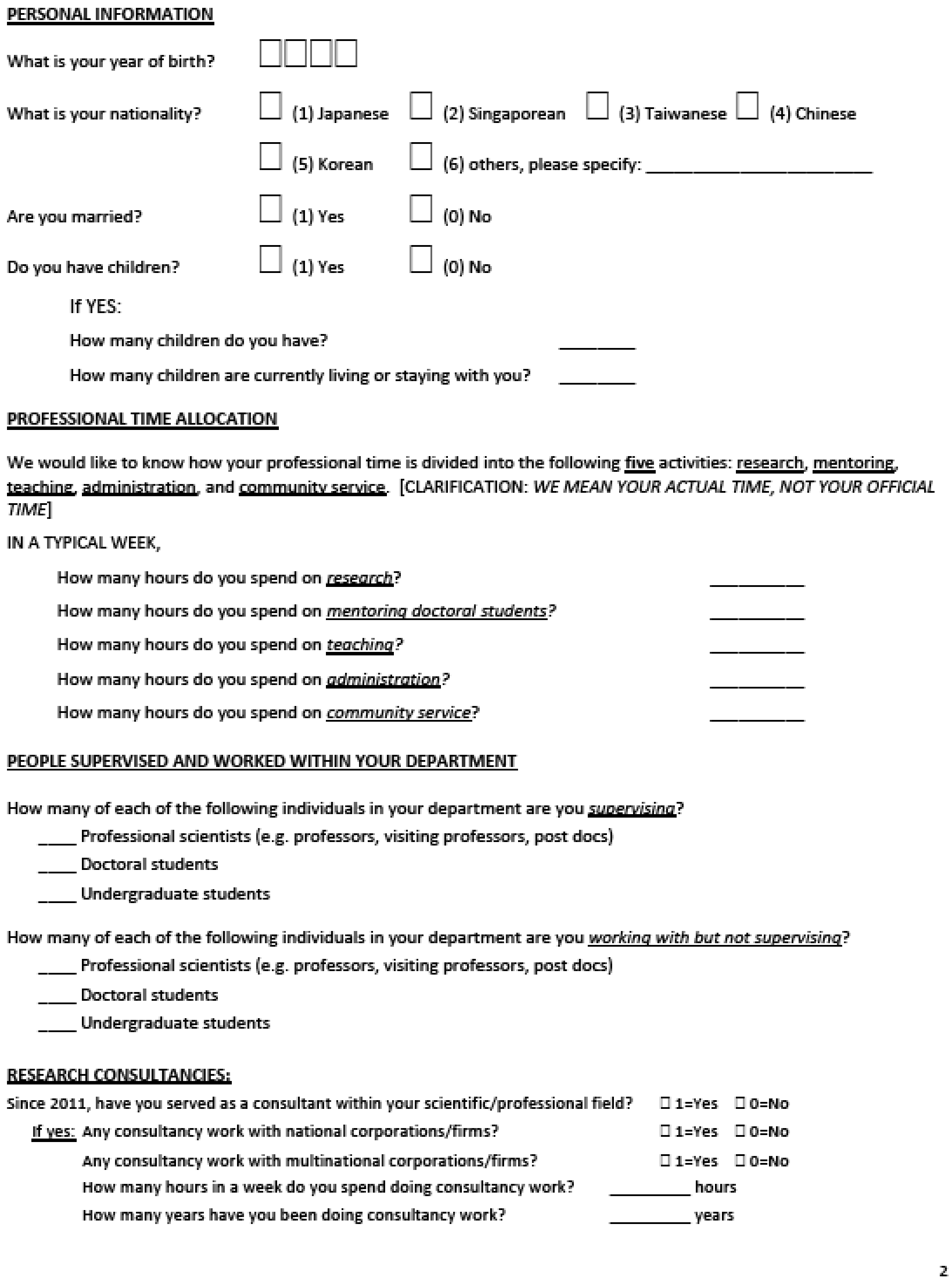
INTERVIEWER: Good morning. My name is ______________________________, a professor/graduate student at Texas A&M International University in Laredo, Texas, USA /Louisiana State University in Baton Rouge, USA/Indiana University in Bloomington, Indiana, USA. I am here to interview you on topics pertaining to your graduate education, training, mentoring experience, research practice and activities. I would like to get your permission to record this interview using a digital voice recorder. Rest assured that all information you provide will be treated confidentially. In the transcription of this interview, no identifying information will be stored or used in the analysis, publication or presentation results. Once transcription has been validated, audiotapes and/or storage media will be erased. (Note for Interviewer: Before starting, please make sure that respondent had signed an informed consent form.)

RESPONDENT IDENTIFICATION

1. RESPONDENT NAME: ____
2. RESPONDENT ID NUMBER: ☐☐☐☐
3. GENDER: ☐ MALE ☐ FEMALE
4. DATE (MM-DD-YY): ☐☐-☐☐-☐☐
5. INTERVIEWER NAME: ____
6. TIME INTERVIEW BEGAN: _______________ 7. TIME INTERVIEW ENDED: _____________
8. UNIVERSITY: ____
9. DEPARTMENT: ____
10. JOB TITILE: ☐ (1) FULL PROFESSOR ☐ (2) ASSOCIATE PROFESSOR ☐ (3) ASSISTANT PROFESSOR ☐ (4) RESEARCH PROFESSOR
11. YEAR JOINED THIS UNIVERSITY AS A FACULTY? ________

PRE- AND POST-DOCTORAL TRAINING

DEGREE	FIELD	UNIVERSITY/INSTITUTION	COUNTRY	YEAR COMPLETED
12. Post-Doc.				
13. Ph.D./D.Sc.				
14. B.Sc.				



PERSONAL INFORMATION

What is your year of birth? ☐☐☐☐

What is your nationality? ☐ (1) Japanese ☐ (2) Singaporean ☐ (3) Taiwanese ☐ (4) Chinese
☐ (5) Korean ☐ (6) others, please specify: ________________________

Are you married? ☐ (1) Yes ☐ (0) No

Do you have children? ☐ (1) Yes ☐ (0) No

If YES:
How many children do you have? ________
How many children are currently living or staying with you? ________

PROFESSIONAL TIME ALLOCATION

We would like to know how your professional time is divided into the following five activities: research, mentoring, teaching, administration, and community service. [CLARIFICATION: *WE MEAN YOUR ACTUAL TIME, NOT YOUR OFFICIAL TIME*]

IN A TYPICAL WEEK,

How many hours do you spend on *research*? __________
How many hours do you spend on *mentoring doctoral students?* __________
How many hours do you spend on *teaching?* __________
How many hours do you spend on *administration?* __________
How many hours do you spend on *community service?* __________

PEOPLE SUPERVISED AND WORKED WITHIN YOUR DEPARTMENT

How many of each of the following individuals in your department are you *supervising*?
____ Professional scientists (e.g. professors, visiting professors, post docs)
____ Doctoral students
____ Undergraduate students

How many of each of the following individuals in your department are you *working with but not supervising*?
____ Professional scientists (e.g. professors, visiting professors, post docs)
____ Doctoral students
____ Undergraduate students

RESEARCH CONSULTANCIES:

Since 2011, have you served as a consultant within your scientific/professional field? ☐ 1=Yes ☐ 0=No
If yes: Any consultancy work with national corporations/firms? ☐ 1=Yes ☐ 0=No
Any consultancy work with multinational corporations/firms? ☐ 1=Yes ☐ 0=No
How many hours in a week do you spend doing consultancy work? _________ hours
How many years have you been doing consultancy work? _________ years

2

RESEARCH COLLABORATIONS

Could you please briefly describe your most important on-going research projects? *EXPLAIN IF NECESSARY*. We would also like to know if each one is collaborative (**that is, done in cooperation with someone in another department or organization**) and where your collaborators are located. Please give a *MAXIMUM OF THREE PROJECTS ONLY*.

1st PROJECT (IF ANY): Please give a couple of key words

Keywords: ____

In what year did this project start? __________

Is this a collaborative project? ☐ 1=Yes ☐ 0=No

If YES,

Where are your collaborators located? (Check boxes for all that apply)

☐ 1=in this institution ☐ 2=in another institution within the country

☐ 3=in another country, please specify country: ____________________

In which sectors are your collaborators working? (Check boxes for all that apply)

☐ 1=academia/university ☐ 2=government research institute or laboratory

☐ 3=industry/corporation/firm (MNCs) ☐ 4=industry/corporation/firm (local)

☐ 5=international organizations (UNDP, FAO) ☐ 6=other, please specify sector: ____________________

2nd PROJECT (IF ANY): Please give a couple of key words

Keywords: ____

In what year did this project start? __________

Is this a collaborative project? ☐ 1=Yes ☐ 0=No

If YES,

Where are your collaborators located? (Check boxes for all that apply)

☐ 1=in this institution ☐ 2=in another institution within the country

☐ 3=in another country, please specify country: ____________________

In which sectors are your collaborators working? (Check boxes for all that apply)

☐ 1=academia/university ☐ 2=government research institute or laboratory

☐ 3=industry/corporation/firm (MNCs) ☐ 4=industry/corporation/firm (local)

☐ 5=international organizations (UNDP, FAO) ☐ 6=other, please specify sector: ____________________

3rd PROJECT (IF ANY): Please give a couple of key words

Keywords: ____

In what year did this project start? __________

Is this a collaborative project? ☐ 1=Yes ☐ 0=No

If YES,

Where are your collaborators located? (Check boxes for all that apply)

☐ 1=in this institution ☐ 2=in another institution within the country

☐ 3=in another country, please specify country: ____________________

In which sectors are your collaborators working? (Check boxes for all that apply)

☐ 1=academia/university ☐ 2=government research institute or laboratory

☐ 3=industry/corporation/firm (MNCs) ☐ 4=industry/corporation/firm (local)

☐ 5=international organizations (UNDP, FAO) ☐ 6=other, please specify sector: ____________________

YOUR RESEARCH PROJECTS IN GENERAL:

Total number of research projects you are currently involved in: __________

Total number of research projects you are currently directing (role as principal investigator): __________

Since 2009, how many collaborative projects have you been involved in? __________

PROFESSIONAL NETWORK

I would like to ask about a few specific people, the people who have similar interests or work on the same field as you do. Here, include anyone you talk to, go to for advice, or anyone who comes to you for advice.

	Individuals whom you discuss important matters with about your research	Is this person a current collaborator?		Is this person male or female?		Is this person Singaporean or not?		What is the relationship of this person to you?									Where is this person located?									In which sector is this person currently working?						How long have you known this person?		How do you communicate with this person? (Check all that apply)				In a typical week, about how many days do you interact with this person?	On average, how long do you interact with this person?*	
	Name	Yes	No	Male	Female	Yes	No	my graduate adviser	one of my professors in grad school	my friend from graduate school	my graduate student	my undergraduate student	my research assistant	my peer/colleague	my spouse/partner	others, please specify.	in this department	in another department in this university	in another institution here in Singapore	in China (exclude Hong Kong)	in Hong Kong	in Taiwan	in Japan	in the United States	others, please specify.	academia/university	government research institutes or labs	international organizations (FAO, IDRC)	industry/firms/corporations (MNCs)	industry/firms/corporations (Locally owned)	other, please specify.	no. of years	no of months	Face-to-Face	Phone	Email	Internet (Skype, MSN Messenger)	Number of days (0 to 7)	no. of hours	no. of min.
1																																								
2																																								
3																																								
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* If a respondent reports 20 minutes then entry in these columns would be 0 hours and 20 min.

PROBLEMS ENCOUNTERED IN CURRENT RESEARCH

If each of the following is a problem for you in any of your current research, please rate this on a scale of 1 to 5 with 1 indicating not a problem and 5 indicating a major problem:

PROBLEMS	Not a problem				A major problem
Contacting people when they are needed	1	2	3	4	5
Coordinating schedules	1	2	3	4	5
Length of time to get things done	1	2	3	4	5
Transmitting information	1	2	3	4	5
Getting others to see your point	1	2	3	4	5
Data management and security of information	1	2	3	4	5
Resolving conflicts	1	2	3	4	5
Decisions on a division of work	1	2	3	4	5
Heavy administrative demands	1	2	3	4	5
Heavy teaching load	1	2	3	4	5

PROFESSIONAL ACTIVITIES

In answering the following questions, please think as far back as 2011.

Have you been a member of any scientific/professional organizations? ☐ 1=Yes ☐ 0=No

Have you served on the editorial board of a journal? ☐ 1=Yes ☐ 0=No

Have you held a position in a scientific/professional organization? ☐ 1=Yes ☐ 0=No

Have you been a member of a government committee/advisory group? ☐ 1=Yes ☐ 0=No

Have you served as a reviewer for a scholarly journal? ☐ 1=Yes ☐ 0=No

Have you served as a reviewer for a grant-funding agency? ☐ 1=Yes ☐ 0=No

ALLOCATION OF RESEARCH TIME

In a typical week, how many hours do you spend doing lab work or running experiments? _____

In a typical week, how many hours do you spend supervising or consulting with your doctoral students?* _____

In a typical week, how many hours do you spend writing or working on research manuscripts? _____

REPORTING FOR WORK, BREAK TIME, VACATIONS AND HOLIDAYS

Typically, what time do you come to office? _____ (time; example 8:15 am)

Typically, what time do you go home? _____ (time; example 6:30 pm)

Once at home, do you typically come back to office after dinner? ☐ 1=Yes ☐ 0=No

Typically, at what time/s do you go for tea or coffee breaks? _____ (time; example 10:00 am & 3:00 pm)

On average, how long would tea or coffee break times be? _____ (record in minutes; example 20 min)

Typically, what time do you go for lunch? _____ (time; example 1:15 pm)

On average, how long do you go for lunch? _____ (record in minutes; example 60 min)

Typically, do you work at the office/laboratory on weekends? ☐ 1=Yes ☐ 0=No

In a year, about how many days do you take off for holidays or vacations? _____ (record in days).

RESEARCH PRODUCTIVITY

Publications

Since 2011, have you published a research paper in a journal? ☐ 1=Yes ☐ 0=No

If yes,

Since 2011, in which journals have you published?	How many?
1.	
2.	
3.	
4.	
5.	

Since 2011, how many chapters in books have you published? _______

Since 2011, how many books/edited books have you authored or co-authored? _______

Since 2011, how many technical reports have you written? _______

In the last 12 months, how many research manuscripts have you written? _______

Awards

Since 2011, have you received any scientific or research awards? ☐ 1=Yes ☐ 0=No

If yes,

How many are national awards? _______

How many are international awards? _______

Grants

Since 2011, have you received any research grants? ☐ 1=Yes ☐ 0=No

If yes,

How many are funded by your university? _______

How many are nationally funded grants? _______

How many are internationally funded grants? _______

Patents

Since 2011, have you generated any patents? ☐ 1=Yes ☐ 0=No

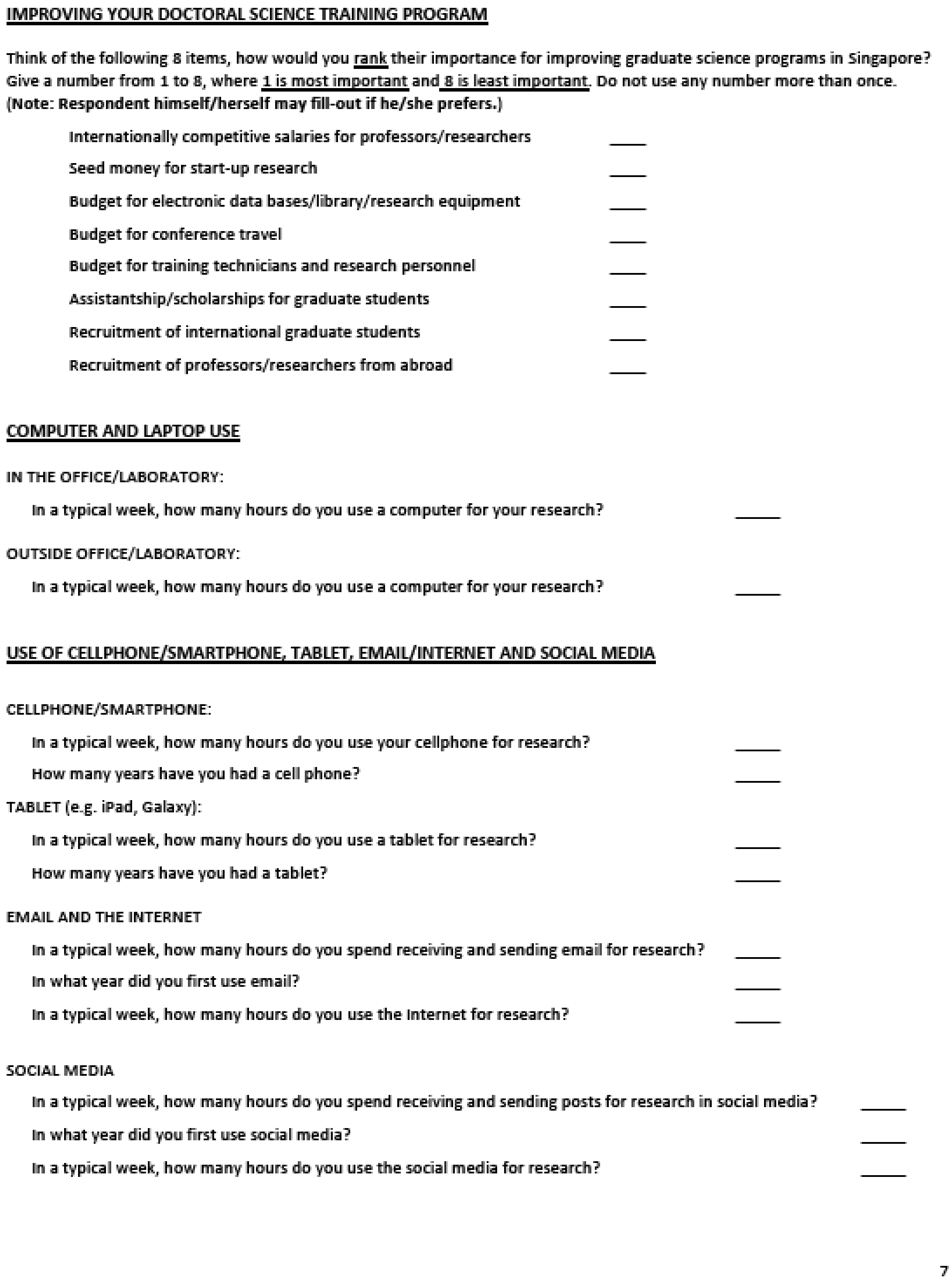
If yes,

How many patents have you generated? _______

In which country is patent 1 registered? ________________

In which country is patent 2 registered? ________________

In which country is patent 3 registered? ________________



IMPROVING YOUR DOCTORAL SCIENCE TRAINING PROGRAM

Think of the following 8 items, how would you rank their importance for improving graduate science programs in Singapore? Give a number from 1 to 8, where 1 is most important and 8 is least important. Do not use any number more than once.
(Note: Respondent himself/herself may fill-out if he/she prefers.)

Internationally competitive salaries for professors/researchers ____
Seed money for start-up research ____
Budget for electronic data bases/library/research equipment ____
Budget for conference travel ____
Budget for training technicians and research personnel ____
Assistantship/scholarships for graduate students ____
Recruitment of international graduate students ____
Recruitment of professors/researchers from abroad ____

COMPUTER AND LAPTOP USE

IN THE OFFICE/LABORATORY:

In a typical week, how many hours do you use a computer for your research? _____

OUTSIDE OFFICE/LABORATORY:

In a typical week, how many hours do you use a computer for your research? _____

USE OF CELLPHONE/SMARTPHONE, TABLET, EMAIL/INTERNET AND SOCIAL MEDIA

CELLPHONE/SMARTPHONE:

In a typical week, how many hours do you use your cellphone for research? _____
How many years have you had a cell phone? _____

TABLET (e.g. iPad, Galaxy):

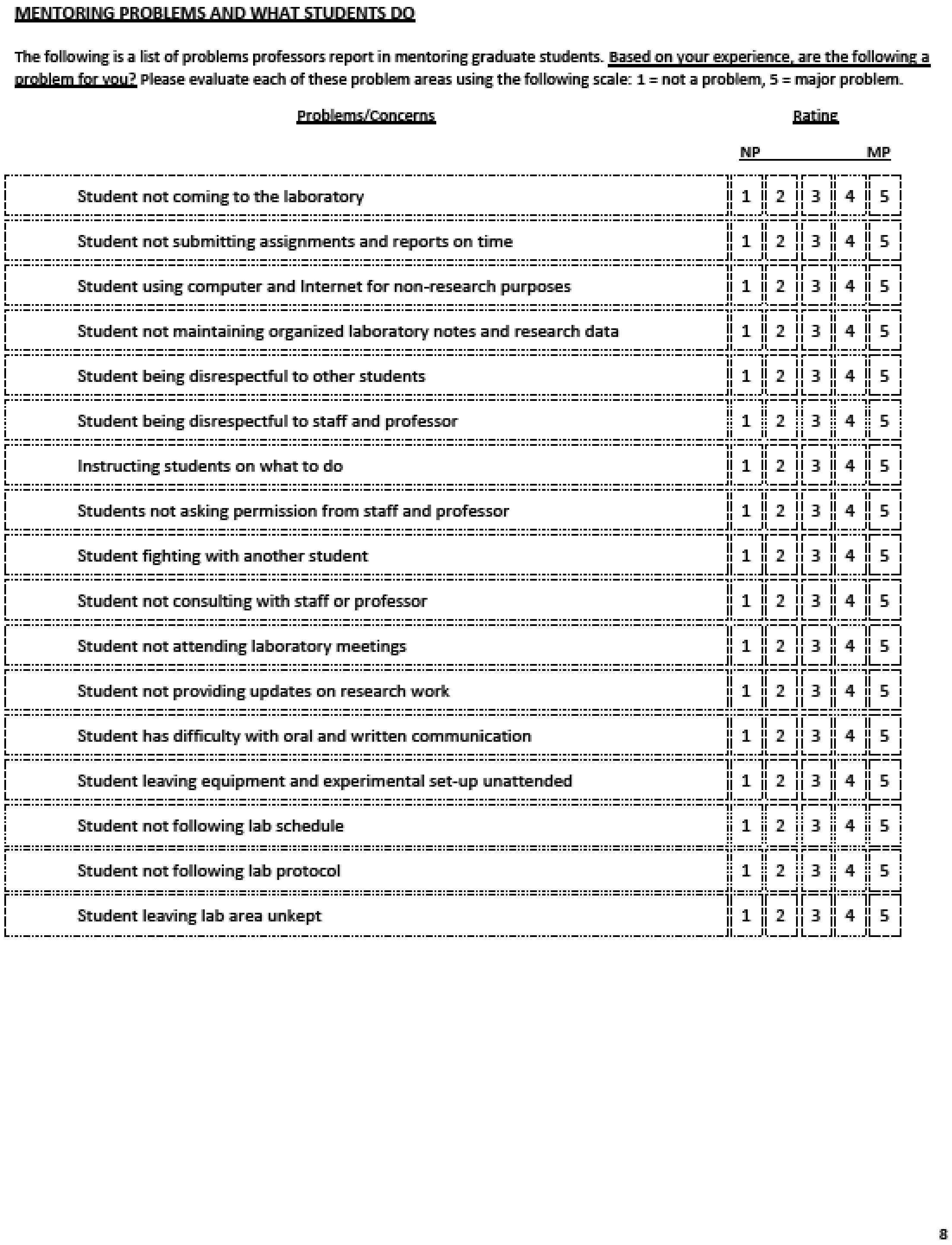
In a typical week, how many hours do you use a tablet for research? _____
How many years have you had a tablet? _____

EMAIL AND THE INTERNET

In a typical week, how many hours do you spend receiving and sending email for research? _____
In what year did you first use email? _____
In a typical week, how many hours do you use the Internet for research? _____

SOCIAL MEDIA

In a typical week, how many hours do you spend receiving and sending posts for research in social media? _____
In what year did you first use social media? _____
In a typical week, how many hours do you use the social media for research? _____



MENTORING PROBLEMS AND WHAT STUDENTS DO

The following is a list of problems professors report in mentoring graduate students. Based on your experience, are the following a problem for you? Please evaluate each of these problem areas using the following scale: 1 = not a problem, 5 = major problem.

Problems/Concerns	Rating				
	NP				MP
Student not coming to the laboratory	1	2	3	4	5
Student not submitting assignments and reports on time	1	2	3	4	5
Student using computer and Internet for non-research purposes	1	2	3	4	5
Student not maintaining organized laboratory notes and research data	1	2	3	4	5
Student being disrespectful to other students	1	2	3	4	5
Student being disrespectful to staff and professor	1	2	3	4	5
Instructing students on what to do	1	2	3	4	5
Students not asking permission from staff and professor	1	2	3	4	5
Student fighting with another student	1	2	3	4	5
Student not consulting with staff or professor	1	2	3	4	5
Student not attending laboratory meetings	1	2	3	4	5
Student not providing updates on research work	1	2	3	4	5
Student has difficulty with oral and written communication	1	2	3	4	5
Student leaving equipment and experimental set-up unattended	1	2	3	4	5
Student not following lab schedule	1	2	3	4	5
Student not following lab protocol	1	2	3	4	5
Student leaving lab area unkept	1	2	3	4	5

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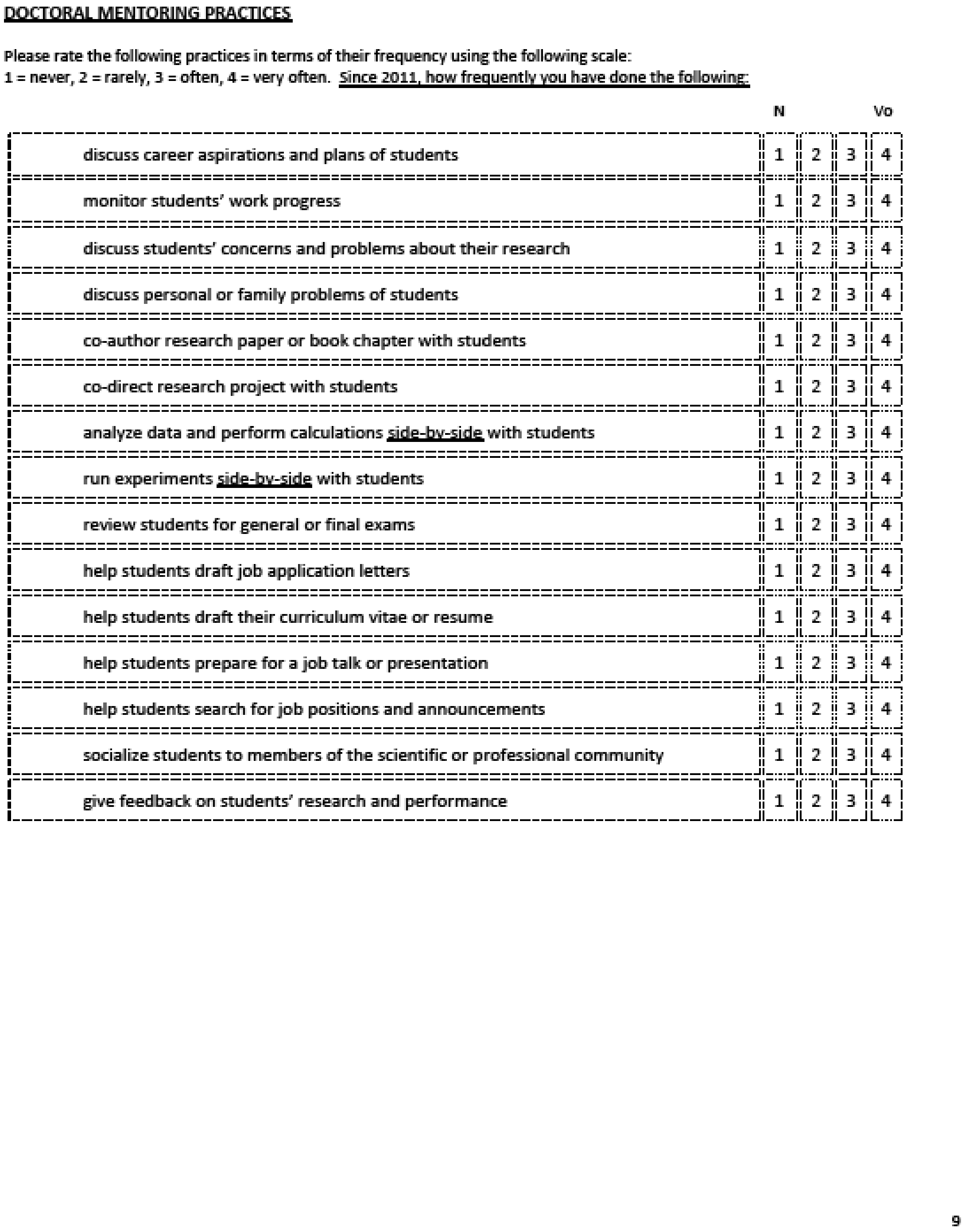

DOCTORAL MENTORING PRACTICES

Please rate the following practices in terms of their frequency using the following scale:
1 = never, 2 = rarely, 3 = often, 4 = very often. Since 2011, how frequently you have done the following:

	N			Vo
discuss career aspirations and plans of students	1	2	3	4
monitor students' work progress	1	2	3	4
discuss students' concerns and problems about their research	1	2	3	4
discuss personal or family problems of students	1	2	3	4
co-author research paper or book chapter with students	1	2	3	4
co-direct research project with students	1	2	3	4
analyze data and perform calculations side-by-side with students	1	2	3	4
run experiments side-by-side with students	1	2	3	4
review students for general or final exams	1	2	3	4
help students draft job application letters	1	2	3	4
help students draft their curriculum vitae or resume	1	2	3	4
help students prepare for a job talk or presentation	1	2	3	4
help students search for job positions and announcements	1	2	3	4
socialize students to members of the scientific or professional community	1	2	3	4
give feedback on students' research and performance	1	2	3	4

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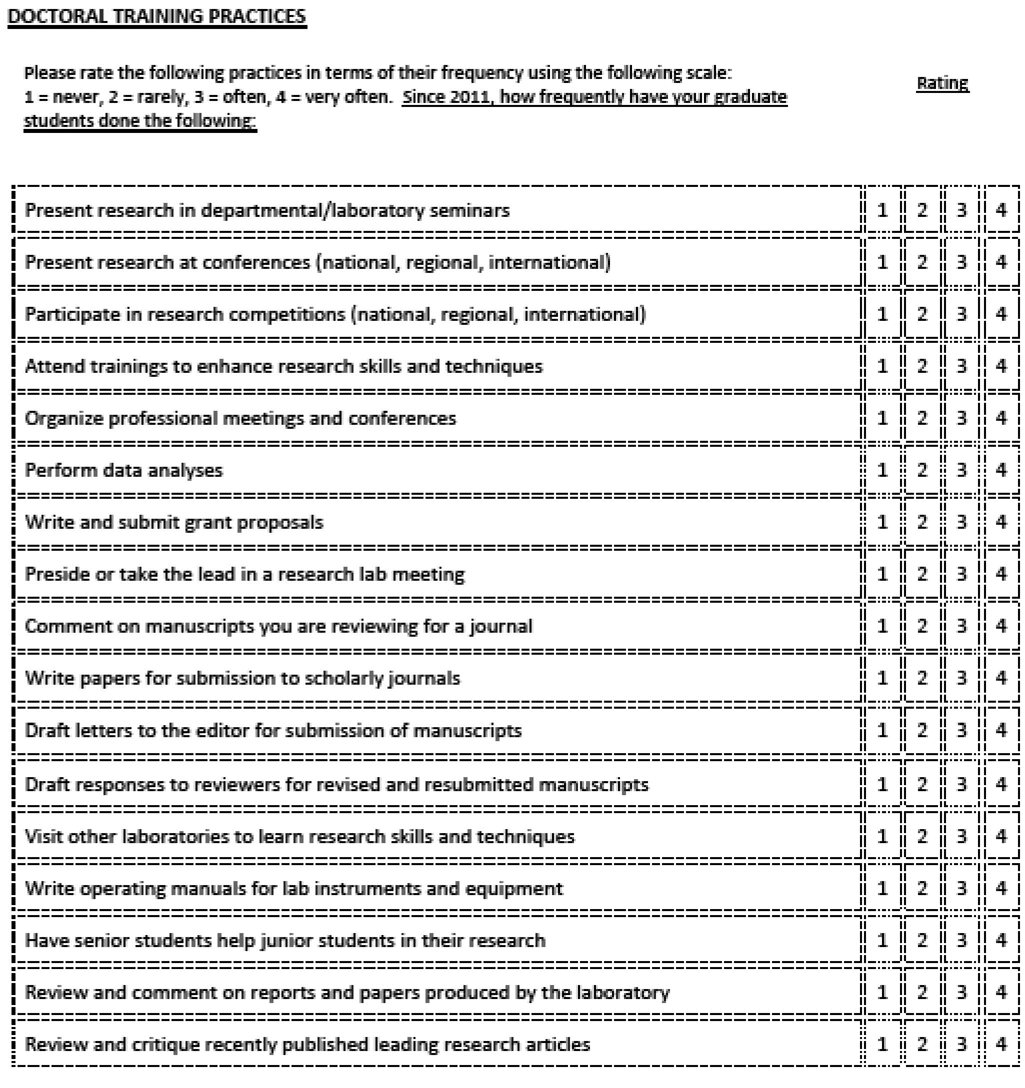

DOCTORAL TRAINING PRACTICES

Please rate the following practices in terms of their frequency using the following scale: 1 = never, 2 = rarely, 3 = often, 4 = very often. Since 2011, how frequently have your graduate students done the following:

	Rating			
Present research in departmental/laboratory seminars	1	2	3	4
Present research at conferences (national, regional, international)	1	2	3	4
Participate in research competitions (national, regional, international)	1	2	3	4
Attend trainings to enhance research skills and techniques	1	2	3	4
Organize professional meetings and conferences	1	2	3	4
Perform data analyses	1	2	3	4
Write and submit grant proposals	1	2	3	4
Preside or take the lead in a research lab meeting	1	2	3	4
Comment on manuscripts you are reviewing for a journal	1	2	3	4
Write papers for submission to scholarly journals	1	2	3	4
Draft letters to the editor for submission of manuscripts	1	2	3	4
Draft responses to reviewers for revised and resubmitted manuscripts	1	2	3	4
Visit other laboratories to learn research skills and techniques	1	2	3	4
Write operating manuals for lab instruments and equipment	1	2	3	4
Have senior students help junior students in their research	1	2	3	4
Review and comment on reports and papers produced by the laboratory	1	2	3	4
Review and critique recently published leading research articles	1	2	3	4

INTERACTION WITH DOCTORAL STUDENTS

The following is a list of bi-polar adjectives that describes advisers' interactions with their graduate students. Please rate each pair of adjectives based on your own personal experiences as an adviser.

Face-to-face	-3	-2	-1	0	1	2	3	*Technology-mediated*
Formal	-3	-2	-1	0	1	2	3	*Informal*
Frequent	-3	-2	-1	0	1	2	3	*Seldom*
One-way	-3	-2	-1	0	1	2	3	*Two-way*
Quick talks	-3	-2	-1	0	1	2	3	*Long discussions*
Structured	-3	-2	-1	0	1	2	3	*Unstructured*
General/Broad	-3	-2	-1	0	1	2	3	*Specifics/Detailed*
Planned	-3	-2	-1	0	1	2	3	*Unplanned*

WORKING IN THE RESEARCH LABORATORY

The following is a list of bi-polar adjectives that describes work environment in a research laboratory. Please rate each pair of adjectives based on your own personal experiences in such a setting.

Competitive	-3	-2	-1	0	1	2	3	*Cooperative*
Structured/hierarchical	-3	-2	-1	0	1	2	3	*Unstructured/non-hierarchical*
Busy	-3	-2	-1	0	1	2	3	*Relaxed*
Supportive	-3	-2	-1	0	1	2	3	*Adversarial*
Friendly	-3	-2	-1	0	1	2	3	*Unfriendly*
Open communication	-3	-2	-1	0	1	2	3	*Close communication*
Authoritarian	-3	-2	-1	0	1	2	3	*Democratic*
Has privacy	-3	-2	-1	0	1	2	3	*Has no privacy*
Low supervision	-3	-2	-1	0	1	2	3	*High supervision*

QUALITATIVE QUESTIONS:

1. *MOTIVATION TO PURSUE GRADUATE STUDIES: What made you decide to pursue graduate studies? [[PROBE: How did you decide which department or which university to pursue your graduate studies? Who influenced you -- directly or indirectly -- to pursue graduate studies?]]*

2. *COLLABORATIONS: What are advantages of collaborations? What are disadvantages of collaborations? In your experience, do collaborations result in increased productivity? Or does increased productivity result in collaborations? [[PROBE: What can you say about how professional networks help or impede scientific collaboration? What can you say about how scientific collaboration helps or impedes research productivity? What can you say about collaborations with industry, government, and international organizations]]*

3. *PRODUCTIVITY: What does it mean to be a productive researcher in your department? How about in your field of study? Can you tell me how professional networks help or impede research productivity? [[PROBE: How is research productivity measured? What incentives are there for researchers to be productive?]] What do you do to make students become more productive?*

4. *DIGITAL TECHNOLOGIES: What kinds of information and communication technologies (e.g. email, Internet, cellular phones, and other technologies) are useful to your research? Please describe their uses? How do these digital technologies impact learning new skills and techniques? How do these technologies change the way you do your research? [PROBE: How do these technologies change the way you do networking, mentoring, and collaborating with other researchers in the fields]*

5. *MENTORING: Please tell me about how you mentor students and why you chose that particular style. How do you encourage students? What are the characteristics of good mentoring? What makes a good mentor?*

6. *LABORATORY STRUCTURE: How do you set up the structure of the lab in order to foster students' learning? How do you set up the structure of the lab so it would maximize your productivity? Is there anything not working well in that current lab structure? Please tell us what they are, if any.*

THANK YOU VERY MUCH!
[[NOTE TO INTERVIEWER: Please make sure to close and save the digital recording for this session, and take note of the following pieces of information as stored in your recorder.]]

Digital voice recorder no: _________
Folder: _________
File No.: _________

VITA

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