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An Empirical Evaluation of Developmental Networks and Mentoring Practices Effect on Doctoral Science Training

Jorge L. Aviles

AN EMPIRICAL EVALUATION OF DEVELOPMENTAL NETWORKS AND MENTORING PRACTICES EFFECT ON DOCTORAL SCIENCE TRAINING

A Thesis

by

JORGE LUIS AVILES

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

MASTER OF ARTS

August 2015

Major Subject: Sociology

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ABSTRACT

An Empirical Evaluation of Developmental Networks and Mentoring Practices Effect on Doctoral Science Training (August 2015)

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This study aimed at examining the impact of doctoral mentoring practices (DMP) and of developmental networks (DN) on the doctoral training practices (DTP) of students enrolled in selected elite doctoral science programs in three East Asian countries. It focuses on these social aspects that potentially enhance and/or diversify training practices that develop scientific occupational competencies. The recognition that mentoring during career development may be available from a variety of individuals beyond the traditional dyadic mentor-mentee relationship led this study to examine the impact of students' developmental networks. The approach taken is novel in that the developmental network typology has yet to be systematically and empirically examined. The population investigated comprised students in chemical science doctoral training programs at elite universities in Japan, Singapore, and Taiwan. A sample of n = 115 students, stratified by university and by country, participated in structured face-to-face interviews that collected information on DMP, DTP, and egocentric networks. Network information was utilized to identify respondents' developmental network type based on diversity of alters' sector (e.g. academia, government, industry, etc.) and ego-alter tie strength. Two sets of principal component analysis, one for the 15 original DMP items and another for the 17 original DTP items, were performed to examine the effect of DN and of DMP on DTP. It was found that students who reported that their advisor engaged in mentoring activities that involved career and psychosocial support also reported enhanced engagement in leadership-driven training practices. Enhanced engagement with sources of training and learning outside of the lab was also found. There was no evidence that developmental network types influenced DTP. Hence, it is recommended that institutions of higher education formulate and monitor the outcomes of policies that foster the development of mentoring practices among faculty. This would aid in the preparation of doctoral students for work within and outside of academia. Further exploration and improvement of the empirical application of the developmental network typology in doctoral science training is also suggested.

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1. INTRODUCTION

1.1 Background

A fundamental component of the doctoral training experience is the subject of socialization and the influence that actors have on student experiences and outcomes (Delamont et al., 2005). Much has been discussed about the effect that faculty advisors or mentors can have on what a doctoral student does, thinks, or achieves throughout the course of their training (Delamont and Atkinson, 2001; Gardner, 2008; Paglis et al., 2006; Ynalvez et al., 2014) in addition to the role that peers may play through the doctoral experience (Eby and Dolan, 2015; Martin and Ko, 2011). It is this recognition of the importance of others that guides the search for connections between experiences in doctoral studies and how one becomes a professional scientist with the aid of developmental networks (Baker and Lattuca, 2010).

1.2 Research Problem

Incorporating a developmental network perspective to an investigation of doctoral training practices assists in clarifying what effect developers have on the training activities of doctoral students[1]. Since doctoral training occurs within a social context with its associated structure, norms, and practices (Baker and Lattuca, 2010; Campbell, 2003), doctoral training programs are a fertile source for elucidating the processes by which a scientist in training transitions from student to a working professional scientist (Delamont et al., 2005). Further, doctoral science programs merit investigation as what is demanded of future professional scientists is expressed through academia, government, and industry (Thune, 2010). Doctoral

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The journal model for this thesis is Research Policy.

[1] The term ‘developers’ specifically refers to Kram’s (1988) description of individuals who serve a developing role by providing mentees with career and psychosocial support as they progress through their professional career within an organization.

students who today enter a science-training program will experience this social milieu such that the outcomes of their training and whether they have developed scientific occupational competencies may be linked to variations in aspects of their training. The resultant research question is: do doctoral mentoring practices and developmental networks structure scientific occupational competencies?

1.3 Objectives

This study aimed to achieve three objectives. The first was to discover and detail the training practices of students within selected elite science training programs in three East Asian countries[2]. The focus on this geographical region is in response to the scientific output of leading East Asian countries that has contributed to their positioning within a global economy (Hien, 2010). Additionally, the insights provided by investigations of foreign academic science training systems allows shaping a global perspective on how countries are developing basic research that is intertwined with advances produced by industry (Pavitt, 1998).

This study was guided by the work of Ynalvez et al. (2014). However, rather than focusing on students' research output as outcome, this study focused on training practices as an outcome for chemical science doctoral students in Japan, Taiwan, and Singapore. It is a cross-sectional analysis of what doctoral students in these programs claim to have done as a part of their training.

Second, it aimed to contribute to the literature on mentoring and development by supporting the application of developmental network theory to the doctoral experience as forwarded by Baker and Lattuca (2010) and by empirically validating the Higgins and Kram (2001) developmental network typology. The rational for applying the theory of developmental

[2] The three countries included are Japan, Singapore, and Taiwan.

networks is rooted in the understanding that the development of a doctoral student is enmeshed in a social learning process that is facilitated by a network of developers (Baker and Lattuca, 2010). That there is an impact on outcomes for graduates based on networking ties, whether established through peer groups (Martin and Ko, 2011), and more generally an impact on professional performance in science based work (Cross and Cummings, 2004; Gable, 2013), attention is drawn to uncovering the characteristics of the egocentric networks identified by doctoral students.

Thirdly, it aimed to affirm the role of the doctoral advisor as a significant source of socialization. Although part of the students' developmental network, the graduate advisor– a component of the structure of doctoral training –is uniquely positioned as a mentor, liaison, and a supervisor responsible for guiding students through their graduate training and socialization within the field (Campbell, 2003; Schnaiberg, 2005). This asymmetrical and dyadic relationship is studied to uncover the impact of practices that stem from the interaction between the advisor and student.

1.4 Significance

An empirical examination was conducted to determine the impact of dyadic interaction with mentor, and generalized interaction with network members on training practices that underpin the development of scientific occupational competencies. Previous research has explored the effects of professional networks and socialization on students' outcomes in productivity and output (Aguilar et al., 2013; Mendoza, 2007). This study adds to this literature by empirically measuring aspects of doctoral training, including doctoral training practices, doctoral mentoring practices, and developmental network type, as a part of a quantitative analysis. Specifically, it presents the measure of developmental network types yet to be empirically articulated in the literature on developmental networks (Molloy, 2005) and analyzes its impact on doctoral training practices. The findings presented may assist institutions, faculty, and students in fostering the development of relationships that engender the career and psychosocial support needed for doctoral students to develop practices and identities as professionals in their field (Baker and Lattuca, 2010).

2. LITERATURE REVIEW

The sociology of science has historically been identified as a field of study neglected by the social sciences (Merton, 1973). This study contributes to this body of knowledge by considering what occurs within the setting of doctoral science training because of variations in developmental relationships that are identified by students and make up their developmental network. Interaction with their developmental network may contribute to a socialization process such that students may develop the skills and knowledge that will foster scientific occupational competence in the profession.

2.1 Socialization: Developing a Scientist

Developing a professional is not simply a matter of applying a prescriptive training program through graduate studies; rather, it is a progression of socialization that relies on interaction with a variety of individuals, entities, and processes as a part of their graduate studies (Baker and Lattuca, 2010; Delamont et al., 2005; Weidman et al., 2001). More generally stated, socialization introduces individuals to the culture and the social structure of a group (Long and Hadden, 1985). In the case of doctoral training, novices are introduced to the culture and social structure of their chosen field, which falls under the umbrella of a social structure and culture of advanced academic studies. Throughout this process existing members are a key factor in socialization (Campbell, 2003) with certain members holding the responsibility of carrying out this process (Long and Hadden, 1985). In academia, professors may principally be assigned the role of socializing new members to the varied activities and requisites for becoming an academic or trained professional. This is carried out through various socializing activities (e.g. co-authorship, conference presentations, brown bag seminars, etc.), that produce members that ultimately develop the competencies and skills required for membership (Campbell, 2003; Long and Hadden, 1985).

In the context of a social group, members may socialize the novice by demonstrating and relaying what knowledge is necessary in addition to skills and competencies needed to meet the group's requirements (Campbell, 2003; Long and Hadden, 1985). For instance, becoming a member of the scientific community requires the acquisition of knowledge not only about scientific theories but also about the skills necessary for demonstrating mastery of concepts and the generation of new knowledge (Delamont et al., 2005). Students must learn the requirements forwarded by their academic discipline in addition to those held by academia in general. Through the course of doctoral study, if not already familiar via their undergraduate studies, students may learn about the dissemination of knowledge through article publication, or the opportunities for knowledge acquisition through conferences and technical trainings. In developing new members of the scientific community, efforts are made to socialize students into recognizing and engaging in the activities and processes that will develop their skills and competencies as potential members of the scientific community; however, professors may be but one source for this socialization.

Students may be socialized into the profession by professors, peers, administrators, collaborators, and other entities (Austin, 2002; Baker and Lattuca, 2010) who share the skills and knowledge necessary to succeed through their doctoral studies in addition to becoming a trained member of the scientific community. While professors may be a primary liaisons for doctoral socialization, others may contribute to the socialization process (Long and Hadden, 1985) in ways that cause differentials in training outcomes. An example of this is the variation in assistance and preparation that students report for acquiring job placement or obtaining the necessary skills for marketability in the workforce after completing a doctoral program (Helm et al., 2012). This suggests that socialization into a profession– scientific or otherwise –may be enhanced by engaging in developmental relationships that improve prospects of becoming professional in their field.

2.2 Developmental Network

Higgins and Kram (2001) cast the developmental network concept as fusion of mentoring and network theory. This conception stems from the observation that a variety of individuals contribute to the professional and the personal development of any one individual. Simply focusing on a mentor-mentee (typically framed and construed as doctoral supervisor and doctoral student) relationship may fail to capture the impact these other relationships may have on development within a shifting environment of training requirements and available resources (De Janasz and Sullivan, 2004; Enders and De Weert, 2004; Kram, 1988). Instead, developmental networks consist of developers that provide different aspects of career and psychosocial support to individuals as they progress through their professional life (Kram and Isabella, 1985). The reception that doctoral experiences are connected to developmental networks has guided inquiry that identifies support of graduate development in relation to developmental networks (Baker and Lattuca, 2010; Sweitzer, 2009).

Dobrow et al. (2012) distinguish between developmental networks, and other constructions of support and social network types. A mentor network, for instance, is described as omitting the various developer relationships that may contribute to development such as relationships with peers, friends, or family – the primary and informal social groups (Dobrow et al., 2012; Higgins et al., 2007). Distinctly, development networks are not restricted to a single sphere and may thus be composed of a variety of developmental relationships that are flexible in the support and resources provided (Dobrow et al., 2012). A doctoral student may have a developmental network composed of friends, family, peers, professors, and professionals that are located in various sectors, including academia, government, industry, or non-governmental organizations. The strength of these relationships and the network diversity are considerations of the makeup of the developmental network typology. See Figure 1. Higgins and Kram (2001) provide this framework of the development network to capture the variety of developmental relationships by examining network diversity and relationship strength. Detailing and connecting the developmental network types to graduate training follows.

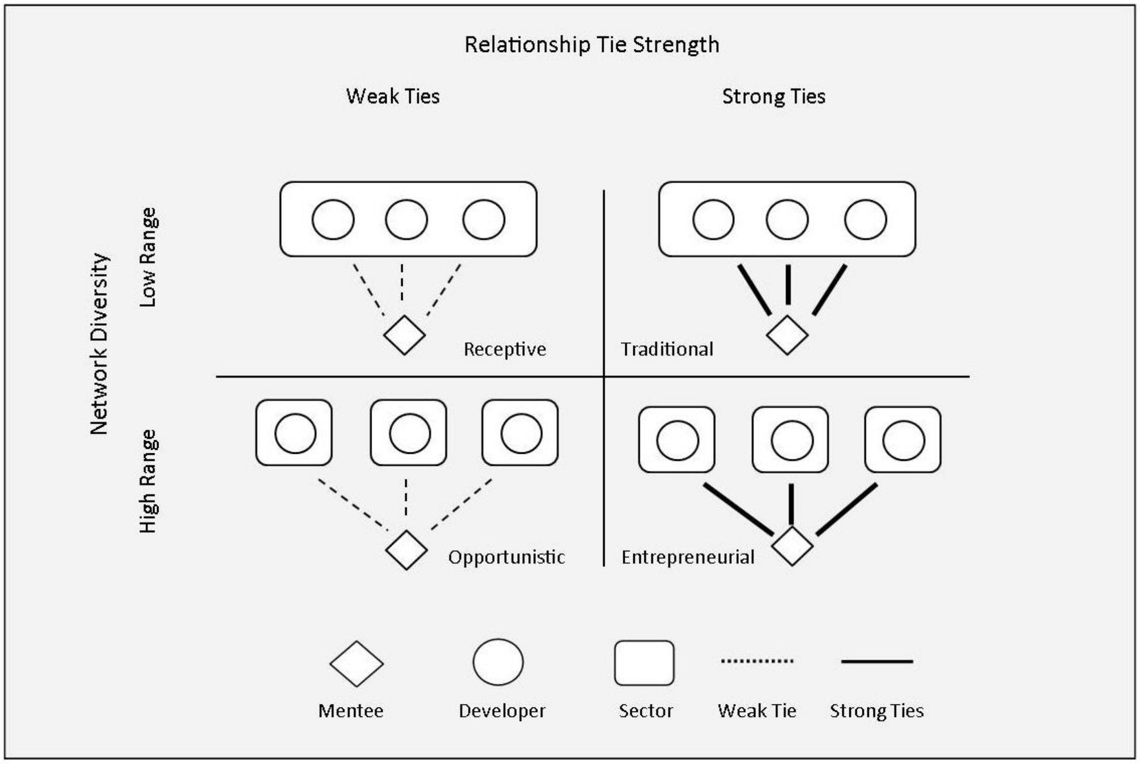

Figure 1: Developmental Network Types

The developmental network categorization casts network diversity as low and high range when the developmental network consists primarily of individuals from one organization or group to multiple organizations or groups respectively (Higgins and Kram, 2001). For instance, a student who identifies five individuals within academia as a part of their developmental network is measured as having a low range as compared to the student who has a high range network with individuals in government, the private sector, or an international organization. The higher range network provides for a variety of development sources such that information available in a high range network will be more diverse in comparison to the redundancy of information available in low range networks (Baker and Lattuca, 2010; Higgins and Kram, 2001). Students may learn about being a member of the scientific community through their relationships with individuals who are within their department or university. They may also learn about science work in a corporate or global context from a high range network that may alter the way students engage in their training.

Also part of the developmental network categorization is relationship (tie) strength. One component of relationship strength described is the frequency of contact where greater frequency of contact indicates greater strength in the relationship tie (Higgins and Kram, 2001). Frequent contact with members of the developmental network would strengthen the relationship ties students have with professors or peers that compose their network whereas less frequent communication may weaken the relationship ties.

From these classifications of aspects of the developmental network, Higgins and Kram (2001) identify four categories of the developmental network based on the possible configurations of high range, low range, strong ties, and weak ties. These developmental network configurations are entrepreneurial, opportunistic, traditional, and receptive. This study specifically identifies and analyzes the impact of the developmental network type on doctoral training practices. What follows is a brief description of these categorizations of the development network as described by Higgins and Kram (2001).

The entrepreneurial development network consists of a high range and strong relationship ties. The student who engages with this type of network must be an active participant in their relationships to building their tie strength. Strong relationships with network members from diverse sectors provide the student with an engaging development environment that maximizes the potential of what can be learned from diverse sources via career and psychosocial support. Conversely, the opportunistic developmental network consists of a high range and weak relationship ties. The diverse sources may be available, but the student may seek assistance or information from these relationships only when necessary. There is a lack of continuous development of the relationship such that its tie strength remains weak.

The traditional developmental network consists of low range and strong relationship ties. Throughout their graduate studies, the student may have incentive to develop strong relationships with a few individuals that are proximally positioned within the laboratory or department they are working under. The receptive developmental network on the other hand consists of low range and weak relationship ties. This network is characterized by a lack of developing stronger relationships among diverse sources such that the student may receive developmental support from those proximally positioned without developing strong relationships. It is recognized that the receptive developmental network type is the most passive of the four as the recipient is not actively engaged in strengthening relationship ties or engaging with diverse members to maximize the available career and psychosocial support (Baker and Lattuca, 2010).

A student's developmental network may consist of a variety of individuals whom the student interacts with. These individuals may contribute to their success during and after their doctoral training (Baker and Lattuca, 2010; Gerholm, 1990). As part of their developmental network, any professor may socialize a student to science practices via an informal relationship such that the student and professor may regularly discuss projects and issues without the foundation of an institutional mentor and mentee relationship. These relationships are a factor in science training that may vary in presence at the micro level and thus may vary the outcomes for students.

The impact of relationships on practices during doctoral training is not limited those relationships between professors and students. For instance, Feldon et al. (2011) describe that those graduate students who engage in teaching demonstrate greater quality in the design of their experiments, while Hunt et al. (2012) show that graduate students who teach utilize formal and informal networks of peers to obtain information about teaching practices. Though this study is not focused on the outcomes of teaching, the preceding examples highlight the role of networks in doctoral training practices, in this case teaching, which is demonstrated as having a meaningful impact on the training outcomes of the student.

There are additional examples of the role of peers in development throughout a period of doctoral training. Martin and Ko (2011) outline the various benefits they identified through their graduate experience that included the formation of a peer support group. They report positive experiences that allowed for their professional development via sharing of experiences, difficulties, ideas, support, and information. The peer support group additionally provided an avenue for exploring successful ways to navigate associations with mentors.

In addition to the doctoral advisor, peers are one example of the type of individuals that may be present in students' developmental networks. The connection to peers may occur through formal or informal structures of interaction. However, there is a distinction between the roles that these support entities may play when compared to those of the doctoral advisor.

2.3 Mentee Experience

Though there may be varying roles doctoral faculty identify for themselves (Lechuga, 2011), there is a common understanding that faculty members play a significant role in socialization (Campbell, 2003; Gerholm, 1990; Lechuga, 2011; Merton, 1973; Paglis et al., 2006; Schnaiberg, 2005). Campbell (2003) specifically discusses the contributions of doctoral science mentors in the training of future scientists. He identifies science faculty mentors as teachers, trainers, recruiters, supervisors, and career advisors. This circumstance places faculty mentors in roles that shape the day to day experiences of the student.

Additionally, Campbell (2003) outlines the various ways that mentors assist in the socialization of students throughout their graduate career whether it is through teaching, relaying expectations of the field, and assisting in identifying prospects for post-graduation placement. The relationship between student and mentor may thus affect two notable aspects of doctoral training. The first is in providing formal guidance as to what the student will be doing day to day. Secondly, the mentor assists the student in framing their activities towards career development. These aspects may be examined for associations with enhanced or diversified training. Where negative associations are found in mentor practices and student practices, there is room to consider the impact of problems with mentors from students' perspectives.

For instance, Paglis et al. (2006) found a differential in mentoring for students that began their graduate program with indicators of promising performance. If mentors demonstrate differences in their mentoring relationships based on their perceptions of students' potential, then there is merit in attempting to discover the possibility for students to be socialized into the scientific profession in varying degrees. One can imagine a scenario where a favored student might be encouraged to participate in a range of graduate training activities, such as attending conferences or submitting grant proposals, while others are not encouraged to the same degree. The differential in mentoring may produce positive or negative perceptions from the perspective of the student.

Eby et al. (2000) offer an overview of negative mentoring experiences as reported in a study of protégés' past professional experiences. The negative experiences reported highlight issues in for example, "work style," "personality," "self-absorption," "lack of mentoring experience," "technical incompetency," and "general dysfunction" (Eby et al., 2000). This study is guided by these findings and extends the consideration of mentoring problems to doctoral mentoring practices. These considerations focus on the students' perspective of problems that have been encountered with their doctoral advisor.

The previous discussion serves to distinguish the significance of the doctoral advisor from the rest of the developmental network. While the doctoral mentor may be embedded within a student's network, their role in doctoral training is defined by structural prescriptions that cannot be wholly subsumed by another network member. This distinction leads to the separation of advisor from the rest of the developmental network with respect to identifying the impact the mentee's experience, negative or positive, may have on the doctoral training practices that contribute to the development of scientific occupational competencies.

2.4 Scientific Occupational Competence

The conception of scientific occupational competence resonates with the "triple helix" of industry, government, and academia that is in need of a workforce trained to do more than conduct academic research (Thune, 2010). Ellstrom (1997) describes occupational competence as a fusion of capacities ranging from social to motor skills in addition to values and intellect. To summarize, it is a summation of the capabilities of the individual, or group, as directed in the potential of accomplishing a task or approaching a situation. Ellstrom distinguishes that when particular competencies are requisite in, for example, a job it is understood as a qualification rather than a competency (1997). Modern scientific training calls for competencies that allow students of the sciences to be prepared for work beyond what is expected in academia as the needs of society evolve (Thune, 2010; Wiesel and Banda, 2002).

It is important to distinguish between competence and scientific occupational competence as it is forwarded here. The use of the term competence in the vernacular application typically refers to an essence of capabilities. The case is made, however, that competence is related to the way beings interface with their social and physical surroundings and that such interaction is motivationally driven rather than passively experienced (White, 1959). Further, the development and application of competencies, in connection with motivational aspects, is cast as being linked with satisfaction with one's work (Nardine, 1977). The development of competencies in professional science occurs over a time span where motivation may be sustained while developing an appreciation for the relevance of the varied training activities undertaken.

In the case of doctoral science training, the development of competencies is an active progression that occurs as the student experiences the socialization process that leads to the engagement of training practices (Delamont et al., 2005). Thus scientific occupational competencies are cast as being actively developed rather than inherent, or passively, acquired. Students enter their program with the motivation to develop their competencies in the sciences, but their social environment may influence the training practices throughout their program such that the training experience of each student may be experientially unique and motivated. Such variation in developing competencies during a doctoral program is of concern when attempting to formulate a program that incorporates the formal and informal curriculum so as to ensure proper graduate training (Sullivan, 1991).

In articulating the curriculum for doctoral training programs, Sullivan (1991) calls for programs to explicitly incorporate informal curriculum in addition to the formal curriculum. She describes the formal curriculum as developing the acquisition and application of knowledge, such as within a classroom context, with a gradual increase in autonomy through the progression of the graduate program (1991). Conversely, informal curriculum relates to auxiliary training opportunities, which students may not fully exploit, that socializes students into the profession and promotes autonomy, such as attending trainings, participating in peer support groups, or experiencing the journal submission process (1991). Including the informal curriculum as an explicit part of graduate training may diminish the differential in training practices that form a differential in competencies necessary to engage with work post-graduation (Floyd Hamilton and Eckstein, 1972).

There is also the issue of the value students may place on their acquisition of competencies through their graduate studies as opposed to simply working towards obtaining credentials awarded in completing a graduate program (Stodt and Thielens, 1985). Supposing that through the socialization process the values of competent scientific work may be strengthened, the developmental network stands to play a critical role in combating credentialism such that future scientists may be ready to fulfill the roles established by a society that seeks a competent individual. If scientists in doctoral programs are to be shaped through their training into an individual capable of fulfilling the variety of occupations within and outside of academia, the degree to which scientific occupational competency is developed via training practices is a significant point to consider. As such, there is room to forward a conception of scientific occupational competence to capture the particular competencies that are developed through the doctoral science training experience.

2.5 Theoretical Framework

What has been discussed at this point is the development of scientific occupational competencies through doctoral training practices that are molded by the socialization of future scientists as they interact with their advisor, typically a formal relationship, and the rest of the developmental network, which can include any developer, such as peers or family members, identified by the student (Higgins et al., 2007). This study, guided by the work of Ynalvez et al. (2014), is as an extension and expansion of research focused on depicting the phenomena of scientific occupational competency development as captured by a survey of doctoral students in science training programs in three East Asian countries. Guided by theoretical propositions forwarded by Baker and Lattuca (2010) that posit the potential for developmental networks to impact the doctoral students' socialization, this study empirically applies the Higgins and Kram (2001) developmental network typology to an examination of doctoral training practices. Students' developmental network and their doctoral training practices are linked for associations in the variation of doctoral training practices that contribute to the development of scientific occupational competencies.

It focuses on three dimensions of doctoral science training: mentee experience, developmental network configuration, and scientific occupational competencies. The proposed relationships among these dimensions are depicted in the theoretical model found in Figure 2. The developmental network is considered from an egocentric perspective so as to capture the diversity and tie strength of developmental relationships from students' perspectives.

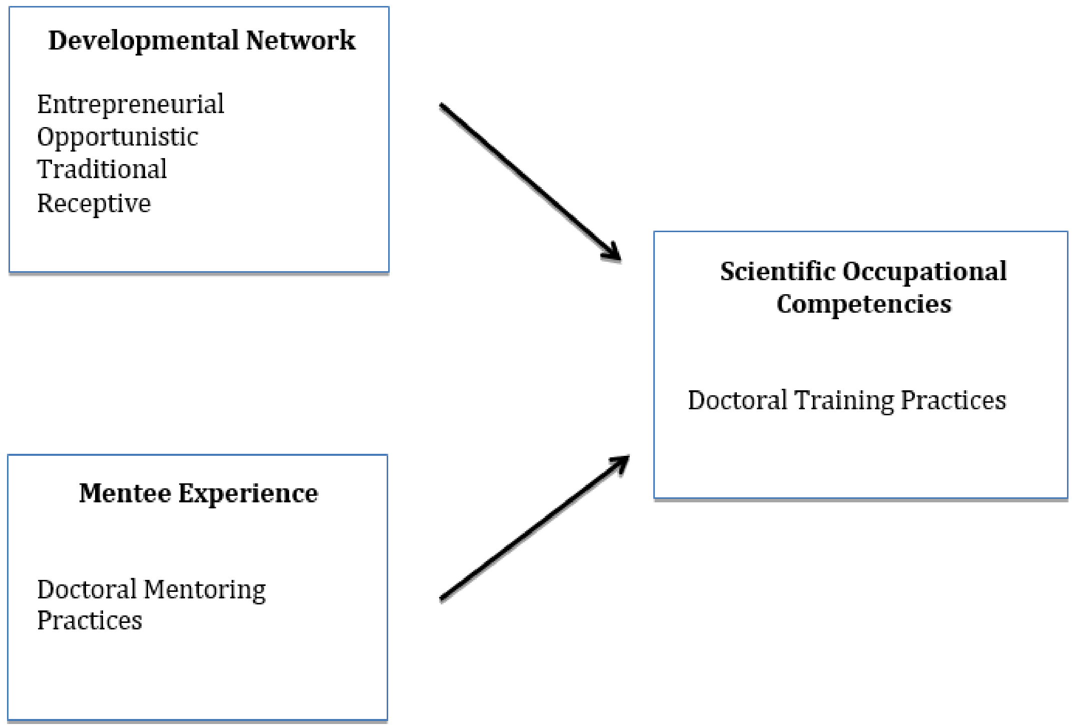

Figure 2: Theoretical Model

The decision to focus on developmental relationships is based students' perspectives. During qualitative interviews there emerged a reoccurring expression of the role that peers and other individuals play in the science training process. Respondents expressed the importance of interaction with other people in the acquisition of skills and solving research problems throughout the course of the students work. This perception is in alignment with what Higgins and Kram (2001) describe as learning at an individual level via interaction with developmental network members.

The research questions that are derived from these theoretical underpinnings specifically ask what variations may be expected in training practices that underlie the development of scientific occupational competencies. It considers whether the developmental network type and mentoring practices are associated with variations in students' doctoral training practices. The following set of core hypotheses is forwarded:

H1: If students report their advisor as more frequently engaging in diverse mentoring practices, they will self-report enhanced and/or diverse doctoral training practices.
H2: If students have a traditional, opportunistic, or entrepreneurial developmental network, they will self-report enhanced and/or diverse doctoral training practices.
H3: If doctoral mentoring practices are negatively associated with self-reports of doctoral training practices, these will be positively correlated with mentoring problems.

The first hypothesis, H1, posits that as students report their advisor as engaging with greater frequency in various mentoring practices, students' self-report of engaging in greater frequency with various doctoral training practices will occur. Similarly, H2 forwards that if students have a developmental network type other than a receptive network type, they will self-report greater frequency in engaging in various training practices. The receptive network type was chosen as the reference category as it characterizes the least potential for the student to acquire career or psychosocial support from developers (Baker and Lattuca, 2010; Molloy, 2005). The third hypothesis, H3, contends that if there are negative associations between mentoring practices and training practices, an examination of the correlations between reported mentoring problems and mentoring practices will demonstrate those particular mentoring practices are positively correlated with mentoring problems.

3. MATERIALS AND METHODS

3.1 Study Location and Population

This study draws on the perspectives of students enrolled in chemical science doctoral training programs in universities in Japan, Taiwan, and Singapore. It follows and expands the work of Ynalvez et al. (2014) which examined the experiences of students enrolled in life science programs. For the purposes of anonymity, the universities investigated are labeled Japan 1, Japan 2, Singapore 1, Singapore 2, Taiwan 1, Taiwan 2, and Taiwan 3. The three countries investigated consist of unique historical circumstances that have seen differentials in the development of higher education as the countries work toward engaging in a global knowledge based economy (George, 2006).

3.2 Japan

Japan is an historical worldwide leader in scientific contributions; however, the growth in impact has not kept pace with the rest of East Asia's emerging leaders in scientific contributions (Adams et al., 2010). Though the country has intentionally developed its efforts in science since the 1800s as a source of innovation (Bartholomew, 1989), there are mixed discussions about the role of doctoral education in this process. With respect to doctoral enrollment, Japan has historically exhibited weak numbers in programs that traditionally were construed as preparation for work in academia and less in industry (Ushiogi, 1997). Simply stated, the job market in Japan has not favored the pursuit of doctoral training (Ushiogi, 1993).

Additionally, Japanese universities continue to exhibit narrowed practices subject to hierarchy and male-centered perspectives (Kurokawa, 2008). The experience of Japanese students was important in this study because insulation as part of socialization may have a limiting effect on the diversity of and engagement in doctoral training practices that are otherwise promoted by universities that are open to global influence. That instruction in Japan occurs in the Japanese language (Aguilar et al., 2013) is an example of how practices such as attending international conferences may be limited. The sources of socialization within this system are considered as relevant in the discussion of training activities that prepare students for work in a global context after completing their program.

3.3 Singapore

In recent years, Singapore has made directed efforts to increasing the capacity of its educational system to develop the country's position in a global knowledge based economy (Mok and Lee, 2003). For example, relationships have developed between local universities and foreign universities as a means of strengthening Singapore's education in an international context with aims to attract and develop local and foreign talent as contributors to innovation and knowledge growth (Sanderson, 2002; Sidhu et al., 2011). These relationships provide for a climate of knowledge exchange for students enrolled in programs in Singapore.

Furthermore, Singapore has a recent history in attracting industry to the country as it supports the growth of R&D through funding and partnerships. These partnerships between government and industry entities provide a fertile ground for the development of relationships with developers in government and the private sector. Also, Singaporean instruction is conducted in English (Aguilar et al., 2013) as English is one of the official Singaporean languages. Singapore is included in this study because their students may have the greatest access to a diverse set of developers via the countries' efforts in knowledge growth and have the language to engage in training and communication on a global scale.

3.4 Taiwan

Taiwan has also experienced the growth of graduate education in alignment with a governmental agenda of economic development (Guo, 2000). Though its history has seen limits on the focus of higher education in favor of developing a workforce prepared for industrial work (Hay Woo, 1991), it has been observed that the sciences in higher education have played a role in the economic development in Taiwan over the last decades (Lin, 2004). Taiwan's scientists are primarily natives that have received training abroad or locally in Taiwanese universities which deliver instruction in English and Mandarin Chinese (Aguilar et al., 2013). By circumstance, Taiwan serves as a middle ground between the cosmopolitan setting of Singapore and the dominance of Japanese culture in East Asian science training. The students from Taiwan are included to capture this middle ground in the analysis.

3.5 Sampling

The execution of this study and the population under consideration did not allow for the complete random selection of respondents. Students were informed of the opportunity to participate by a university liaison via departmental announcements, on campus announcements, and word of mouth via students. Respondents self-selected to participate in the study. An overall sample of n = 115 doctoral students enrolled in chemical science programs was included in this study. Representativeness was sought by selecting a similar number of respondents per country and per university within the county.

The number of students interviewed was limited to what could be accomplished during the time present at the study locations, which was determined largely by budgetary constraints. The sample of students comprised 37 students from Japan, 35 from Singapore, and 43 from Taiwan. Representativeness of gender was also considered when possible to avoid underrepresentation of genders. Although monetary compensation was provided for participation in interviews, the integrity and ethical considerations of the project were reviewed and approved by the institutional review board of each participating university including the sponsoring institution.

3.6 Data collection

As part of a National Science Foundation Science of Science and Innovation Policy grant, this survey was conducted in the field by a team of faculty supervisors and graduate students of Texas A&M International University. Three teams were deployed in the countries included in this study. There they conduct structured face-to-face interviews that collected both quantitative and qualitative data from respondents. This author was a part of the team that surveyed in Singapore in the summer of 2013.

The interview included questions about the students' personal attributes, including age and marital status, educational background, and an array of questions related to their doctoral experience and practices. On average interviews lasted between 45 minutes to just over one hour. These interviews were conducted on-site. The names of respondents and of the universities have been anonymized for the purposes of confidentiality. Responses were recorded on a paper based survey instrument and audio recordings were utilized to capture qualitative responses. Quantitative data was entered into SPSS for electronic storage, documentation, and analysis.

Mentee experience is detailed by the reporting of two indicators, mentoring practices and mentoring problems. Mentoring practices include observations from students' perspectives about what their mentor does. This answered questions about whether the mentor talks with students about aspirations and career plans among others. Mentoring problems encompass the perceptions students have about problems regarding their faculty mentor. Questions considered include whether the mentor is responsive to students' needs or available for assistance. For full list of questions pertaining to indicators of mentee experience, see Appendix C and D.

A name generator is a tool for collecting data about individuals within an egocentric network (Marsden, 1990). It allows for the measurement of network range and intensity from the perspective of the doctoral student (ego) by asking questions about those who make up their developmental network (alters), how, and when they interact with alters. Range is conceived in part as the diversity of the network whereas intensity, or tie strength, may be conceived as the frequency of interaction with individuals in the network (Marsden, 1990). The egocentric name generator utilized in this study captures indicators of network range and relationship tie strength by providing the sector in which network members are part of and the duration of contact with each network member in a typical week. These indicators combined allowed the identification of the students' developmental network type.

3.7 Outcome variables

The measures of *scientific occupational competencies* were generated from a series of questions that gauge the degree to which students participate in various doctoral research experiences such as were utilized in Ynalvez et al. (2014). For the purposes of clarity, the label of doctoral training practices is retained in this study as DTP. A principal component analysis was conducted on the 17 original Likert-style questions pertaining to DTP, measured on a scale from 1 = never, 2 = rarely, 3 = often, 4 = very often, to identify components for the statistical analysis of the data through a generalized linear regression model. These items include, for example, whether the student presents in research conferences, participates in research competitions, or visits other labs to learn new techniques. For the full list of questions, see Appendix A.

Similar to Ynalvez et al. (2014), the PC analysis allows for the reduction of the original items into principal components that may be included in a regression analysis. A varimax orthogonal rotation was utilized to clarify the interpretation of the components outlined by the covariance matrix generated by the PCA. Components with eigenvalues above 1.0 were retained and Anderson-Rubin scores were generated for use in the regression analysis. In the case of the DTP components, these scores were used as the outcome variables in the regression analysis.

3.8 Predictor variables

The *developmental network* is measured by self-reported data through an egocentric name generator that asked students to list those individuals who they talk with or go to for advice related to their field and important matters related to their research. Name generators are a cited method of collecting network data about alters within the respondents' network including the attributes of alters and ties (Marsden, 1990). Data from the name generator was examined to determine network diversity as measured by the diversity of sectors in which network members are located in including academia, government, foreign and local industry, international organizations and other sectors. To determine the diversity of the students' developmental network with respect to sector in which an alter is located, the index of qualitative variation (IQV) (Frankfort-Nachmias and Leon-Guerrero, 2010) was calculated for sector variation of each student's network[3]. Students with an IQV of zero were categorized as reporting low range

[3] The index of qualitative variation is a measure from 0 to 1 (or 0% to 100%) of the variability of nominal variables. See Frankfort-Nachmias and Leon-Guerrero (2010) for a detailed definition. $IQV = K(100^2 - \sum Pct^2) / 100^2(K - 1)$ where K = number of categories $\sum Pct^2$ = sum of squared percentages

in diversity of sector configuration of alters and those with and IQV of greater than zero were labeled as high range in diversity for sector configuration of alters.

Relationship tie strength was measured by the mean of the reported duration of contact with alters. Specifically, it was measured by the number minutes reported in contact with alters in a typical week. This alternate measure of tie strength is utilized in to diminish the overestimation of tie strength among colleagues (Marsden and Campbell, 1984). A t-score was calculated for the mean of interaction duration. The sample mean for each country was utilized to calculate the scores for students of that country[4]. Those students with a t-score below zero were identified as having weak ties and those with a t-score at or above the zero were identified as having strong ties. Once these classifications were defined for each respondent, a developmental network type was identified as entrepreneurial (high range and strong ties), opportunistic (high range and weak ties), traditional, (low range and strong ties) and receptive (low range and weak ties). The four network types were coded into three dummy variables (traditional, opportunistic, and entrepreneurial) with receptive networks serving as the reference category. See Figure 2.

A principal component analysis was also conducted on the 15 original items measuring various doctoral mentoring practices DMP. These 15 original Likert-style items, measured on a scale from 1 = never, 2 = rarely, 3 = often, 4 = very often, asked questions about what practices students have observed of their advisor. For example, these items ask whether the advisor discusses career aspirations, discusses the student's concerns about research, or runs experiments side by side with students. Students' responses are based on their perception of how frequently a mentoring practice occurs. See Appendix B for the full list of items.

[4] Student's t-scores were calculated using the formula $t = (\bar{x} - \mu) / (s / \sqrt{n})$ where μ us the country mean.

Mentoring problems (MTP) were included in this analysis as potential correlates of negative outcomes in DTP as a result of DMP. MTP were measured by 15 original Likert style items that ask what problems students have experienced with their advisor. Examples of these questions include whether the advisor is rarely present or if they do not provide feedback on work. DTP and MTP items were examined separately in a principal component analysis. Again, components with an eigenvalue equal to or greater than 1.0 were included and Anderson-Rubin scores were utilized in the analysis. For the full list of original items regarding MTP, see Appendix C.

3.9 Control Variables

The control variables in this study include personal and enrollment attributes. These are composed of the age of student, gender, marital status, a native of program country, and year in the program. Age was included as a continuous measure of years based on the difference between year of survey and year of birth. Gender was measured by a categorical variable with male as the reference category (1= female; 0 = male). The reference category for the marital status categorical variable was not married (1 = married; 0 = not married). Nationality of respondent is coded into whether they are a native to the country in which their program is located (1 = native; 0 = not native). Year in the program was categorized as a dummy variable of classification identifying first and second year students combined as the reference category (1 = 3^{rd}&4^{th} year in program; 0 = 1^{st}&2^{nd} year in program).

4. RESULTS

This section is dedicated to the description of the results generated by the analysis of predictor and outcome variables included in this study. Descriptive statistics are detailed regarding the personal attributes of the students as well as their enrollment attributes that are included as control variables. A similar examination is detailed on the kind of developmental network identified for each respondent with a breakdown of the basic statistics on interaction time with network alters and the diversity of the reported network alter sector. These statistics are also reported for the predictor variables related to the doctoral mentoring practices (DMP), and the outcome dimension of doctoral training practices (DTP). The results of the principal component analysis follow in this reporting. Lastly, the results of the multiple linear regressions examining variations in DTP as associated with DMP and type of developmental network is reported. Correlations for DMP and mentoring problems are described.

4.1 Descriptive Statistics for Personal and Enrollment Attributes

Table 1 shows that the majority of respondents in this sample were male with 29% percent of respondents being female. In Japan, 14% of respondents were female while 43% in Singapore and 32% in Taiwan were female. The percentage of respondents who reported being married was 17%. In Japan, 3% of respondents were married. This is less than the 31% and 16% of respondents in Singapore and Taiwan that reported being married. The mean age of the respondents was 27.7 years with a minimum of 22.0 years and a maximum of 35.0 years in age reported. Students from Taiwan had the greatest average age at 28.8 years with Japan following at 27.1 and Singapore at 26.9.

Table 1. *Descriptive Statistics – Full Sample*

	n[2]	Mean	Median	SD	Minimum	Maximum
A. Personal and Enrollment Attributes						
Gender is female (1=yes; 0=no)	112	0.29	0.00	0.46	0.00	1.00
Age in years	115	27.68	27.00	2.49	22.00	35.00
Native to program country (1=yes; 0=no)	115	0.63	1.00	0.48	0.00	1.00
Is 3rd or 4th year student (1=yes; 0=no)	114	0.57	1.00	0.50	0.00	1.00
Is married (1=yes; 0=no)	115	0.17	0.00	0.37	0.00	1.00
B. Network Characteristics[1]						
Index of qualitative variation for alters' sector (ranges from 0 - 1)	115	0.11	0.00	0.21	0.00	0.70
Diversity in alters' sector (1=yes; 0=no)	115	0.49	0.00	0.86	0.00	1.00
Average time interacting with alters: minutes in a typical week	115	95.91	60.00	118.55	5.00	720.00
Tie strength with alters strong (1=yes; 0=no)	115	0.36	0.00	0.48	0.00	1.00
Developmental network type traditional (1=yes; 0=no)	115	0.23	0.00	0.42	0.00	1.00
Developmental network type opportunistic (1=yes; 0=no)	115	0.11	0.00	0.32	0.00	1.00
Developmental network type entrepreneurial (1=yes; 0=no)	115	0.13	0.00	0.34	0.00	1.00
C. Doctoral Mentoring Practices						
Discuss career aspirations and plans of students	110	2.50	2.00	0.74	1.00	4.00
Monitor student's work progress	110	3.40	3.00	0.62	2.00	4.00
Discuss student's concerns and problems about their research	110	3.27	3.00	0.69	1.00	4.00
Discuss personal or family problems of students	110	1.89	2.00	0.78	1.00	4.00
Co-author research paper or book chapter with students	110	2.84	3.00	1.03	1.00	4.00
Co-direct research projects with students	110	2.53	3.00	1.09	1.00	4.00
Analyze data and perform calculations side by side with students	110	2.33	2.00	1.02	1.00	4.00
Run experiments side by side with students	110	1.47	1.00	0.65	1.00	3.00
Review students for general or final exams	110	1.94	2.00	1.01	1.00	4.00
Help students draft job application letters	110	2.36	2.00	1.08	1.00	4.00
Help students draft their curriculum vitae	110	1.78	2.00	0.92	1.00	4.00
Help students prepare for a job talk or presentation	110	1.95	2.00	0.97	1.00	4.00
Help students prepare for a job positions and announcements	110	2.25	2.00	0.91	1.00	4.00
Socialize students to member of the scientific community	110	2.40	2.00	0.94	1.00	4.00
Give feedback on student's research and performance	110	3.29	3.00	0.78	1.00	4.00
D. Doctoral Training Practices						
Present research in departmental / lab seminars	113	3.00	3.00	0.79	1.00	4.00
Present research at conferences (national, regional, international)	113	2.50	2.00	0.92	1.00	4.00
Participate in research competitions (national, regional, international)	113	1.49	1.00	0.70	1.00	4.00
Attend trainings to enhance research skills and techniques	113	2.19	2.00	0.77	1.00	4.00
Organize professional meetings / conferences	113	1.46	1.00	0.67	1.00	3.00
Perform data analysis	113	3.46	4.00	0.77	1.00	4.00
Write and submit grant proposals	113	1.96	2.00	0.95	1.00	4.00
Preside or take the lead in a research lab meeting	113	2.09	2.00	0.10	1.00	4.00
Comment on manuscripts you are reviewing for a Journal	113	2.18	2.00	1.04	1.00	4.00
Write papers for submission to scholarly journals	113	2.60	3.00	0.88	1.00	4.00
Draft letters to the editor for submission of manuscripts	113	1.73	1.00	0.93	1.00	4.00
Draft responses to reviewers for revised and resubmitted manuscripts	113	2.12	2.00	1.05	1.00	4.00
Visit other laboratories to learn research skills and techniques	113	2.16	2.00	0.94	1.00	4.00
Write operating manuals for lab instruments and equipment	113	2.11	2.00	0.92	1.00	4.00
Have senior students help junior students	113	3.19	3.00	0.81	1.00	4.00
Review and comment on reports and papers produced by the lab	113	2.53	3.00	0.92	1.00	4.00
Review and critique recently published leading research articles	113	2.69	3.00	0.98	1.00	4.00

1. Reference category is receptive developmental network type
2. Missing cases excluded
n = Sample Size
SD = Standard Deviation

The enrollment characteristics for the respondents include whether the respondents are in their first and second or third and fourth year in the doctoral program as well as whether respondents are native to the country in which their program is located. 57% of respondents reported being in their 3rd or 4th year with 33% of Japan, 63% of Singapore, and 72% of Taiwan respondents in the 3rd or 4th year in the program. Overall 63% of students reported being of a nationality native to the country in which their doctoral program is located with 70% of students in Japan being a native of Japan, 88% of Taiwan students being a native of Taiwan, and 26% of students in Singapore being a native of Singapore.

4.2 Descriptive Statistics for Predictor Variables

Table 1 and 2 contain the median values (mdn) for DMP and DTP items. Based on the median values for each item, various items of DMP and DTP were reported as never or rarely occurring with a median value of 1 or 2. Over 50% of respondents reported observing their advisor as never or rarely running experiments side by side with students (mdn = 1.0) or analyzing data side by side with students (mdn = 2.0). It is also reported that never or rarely do advisors discuss the students' career aspirations and plans (mdn = 2.0) or students' personal or family problems (mdn = 2.0), help students draft job application letters (mdn = 2.0), students' curriculum vitae (mdn = 2.0), prepare for a job talk or presentation (mdn = 2.0), prepare students for job positions and announcements (mdn = 2.0), or socialize students to members of the scientific community (mdn = 2.0). Conversely, over half of respondents reported observing their advisor often or very often monitoring students' work progress (mdn = 3.0), providing feedback on research and performance (mdn = 3.0), discussing students' concerns and problems regarding their research (mdn = 3.0), co-author book chapters or research papers (mdn = 3.0), and co-direct research projects with students (mdn = 3.0).

The developmental network type for each respondent was identified through a combined measure of the calculated IQV for each respondent's network range with regard to the sector location of alters and the mean of the number of minutes reported interacting with each alter in a typical week as a measure of relationship tie strength. With a possible IQV ranging from 0 to 1, zero indicating no diversity and one indicating equally distributed diversity, respondents IQV was at a minimum 0 and at maximum .70. The mean IQV for the overall group was .11 with respondents from Japan having a mean of .17, Singapore having a mean of .05, and Taiwan having a mean of .11. IQV was converted into a dummy variable categorizing respondents with an IQV of zero as low in network range and those with an IQV above zero as exhibiting high network range of alters sector (1 = high network range; 0 = low network range). Based on the reported alters sector location, it was found that 49% of respondents exhibit a high network range with the majority of respondents from Japan exhibiting high network range at 76%, Singapore with 23%, and Taiwan with 47%.

Table 2. *Descriptive Statistics by Country*

	n[3]	Overall	Japan	Singapore	Taiwan	Remark[2]
		Mean				
A. Personal and Enrollment Attributes						
Gender is female (1=yes; 0=no)	112	0.29	0.14	0.43	0.32	J ST
Age in years	115	27.68	27.08	26.89	28.84	J S T
Native to program country (1=yes; 0=no)	115	0.63	0.70	0.26	0.88	JS T
Is 3rd or 4th year student (1=yes; 0=no)	115	0.57	0.33	0.63	0.72	J ST
Is married (1=yes; 0=no)	115	0.17	0.03	0.31	0.16	J ST
B. Network Characteristics[1]						
Index of qualitative variation for alters' sector (ranges from 0 -1)	115	0.11	0.17	0.05	0.11	JT ST
Diversity in alters' sector (1=yes; 0=no)	115	0.49	0.76	0.23	0.47	J ST
Average time interacting with alters: minutes in a typical week	115	95.90	51.72	88.12	140.26	JT ST
Tie strength with alters strong (1=yes; 0=no)	115	0.36	0.46	0.34	0.28	JST
Developmental network type traditional (1=yes; 0=no)	115	0.23	0.27	0.26	0.16	JST
Developmental network type opportunistic (1=yes; 0=no)	115	0.11	0.19	0.03	0.12	J ST
Developmental network type entrepreneurial (1=yes; 0=no)	115	0.13	0.19	0.09	0.12	J ST
C. Doctoral Mentoring Practices						
Discuss career aspirations and plans of students	110	2.50	2.70	2.29	2.48	JT ST
Monitor student's work progress	110	3.40	3.27	3.37	3.47	JST
Discuss Students concerns and problems about their research	110	3.27	3.27	3.21	3.28	JST
Discuss personal or family problems of students	110	1.89	1.84	1.54	2.12	JS JT
co-author research paper or book chapter with students	110	2.84	2.97	2.51	3.05	JS JT
Co-direct research projects with students	110	2.53	2.76	2.69	2.35	JST
Analyze data and perform calculations side by side with students	110	2.33	2.00	2.00	2.79	JS T
Run experiments side by side with students	110	1.47	1.43	1.43	1.53	JST
Review students for general or final exams	110	1.94	2.27	1.57	1.86	JT ST
Help students draft job application letters	110	2.36	2.75	1.87	2.47	JT S
Help students draft their curriculum vitae	110	1.78	2.03	1.41	1.86	JT ST
Help students prepare for a job talk or presentation	110	1.95	2.16	2.06	1.77	JST
Help students prepare for a job positions and announcements	110	2.25	2.54	2.00	2.21	JT ST
Socialize students to member of the scientific community	110	2.40	2.86	1.86	2.40	J S T
Give feedback on student's research and performance	110	3.29	3.59	3.27	3.07	J ST
D. Doctoral Training Practices						
Present research in departmental / lab seminars	113	2.12	1.92	2.18	2.23	JST
Present research at conferences (national, regional, international)	113	2.19	2.14	2.26	2.21	J ST
Participate in research competitions (national, regional, international)	113	3.00	3.03	2.80	3.12	JST
Attend trainings to enhance research skills and techniques	113	1.46	1.35	1.29	1.72	JST
Organize professional meetings conferences	113	2.50	3.00	2.09	2.42	JS T
Perform data analysis	113	2.69	2.57	2.51	2.95	JST
Write and submit grant proposals	113	3.46	3.57	3.57	3.28	JT S
Preside or take the lead in a research lab meeting	113	1.96	2.16	1.37	2.30	JST
Comment on Manuscripts you are reviewing for a Journal	113	2.09	2.30	1.89	2.07	J ST
Write papers for submission to scholarly journals	113	2.16	1.92	2.23	2.28	JST
Draft responses to reviewers for revised and resubmitted manuscripts	113	2.18	1.70	2.20	2.56	JS ST
Draft letters to the editor for submission of manuscripts	113	1.49	1.38	1.4	1.62	JST
Visit other laboratories to learn research skills and techniques	113	2.60	2.59	2.57	2.60	JST
Write operating manuals for lab instruments and equipment	113	1.73	1.97	1.69	1.51	JST
Have senior students help junior students	113	2.11	2.27	1.94	2.12	JS T
Review and comment on reports and papers produced by the lab	113	3.19	3.16	2.8	3.58	JS T
Review and critique recently published leading research articles	113	2.53	2.27	2.26	3.02	JS JT

1. Reference category is receptive developmental network type
2. The 'Remark column indicates the results of comparison of means test for the three locations surveyed. JST indicates no differences identified between the three locations. J S T indicates the three locations differ significantly in their means. JS and ST indicates that Japan and Taiwan are significantly different from each other but Japan and Singapore or Japan and Taiwan are not significantly different from each other.
3. Missing cases excluded

n = Sample Size

To measure relationship (tie) strength, the overall mean was calculated for the number of minutes spent in a typical week interacting with respondents' alters. It was then converted into a t-score with sample mean being calculated for each country rather than utilizing the overall sample mean. Overall, the average number of minutes reported by respondents as engaged in interaction with the network alters was 95.91 minutes with Japan exhibiting the lowest mean at 51.72 minutes, followed by Singapore at 88.12 minutes, and Taiwan averaging 140.26 minutes. The pronounced differences in average interaction time per country prompted the use of sample mean per country in the calculation of the t-score of average time for each respondent. Once t-scores were generated, a dummy variable was created to categorize respondents as exhibiting low relationship tie strength and high relationship tie strength (0 = low strength; 1 = high strength). Scores at or above zero were categorized as high strength and scores below zero were categorized as low strength.

With measures of network range regarding alters' sector and tie strength, the developmental network type for each respondent was identified as receptive (low range, low strength), traditional (low range, high strength), opportunistic (high range, low strength), and entrepreneurial (high range, high strength). Twenty-three percent of respondents were categorized as having a traditional developmental network, 11% an opportunistic developmental network, 13% an entrepreneurial developmental network, and 53% a receptive developmental network. Broken down by each country, Japan consisted of 27% traditional, 19% opportunistic, 19% entrepreneurial, and 35% receptive. Singapore consisted of 26% traditional, 3% opportunistic, 9% entrepreneurial, and 62% receptive. Lastly, Taiwan had 16% traditional, 12% opportunistic, 12% entrepreneurial, and 60% a receptive developmental network.

4.3 Descriptive Statistics for Doctoral Mentoring Problems

Problems mentees have experienced with their advisors were included in this study as a potential correlate of mentoring practices that are negatively associated with training practices. The descriptive statistics for 15 Likert style items are included in Table 3. More than 50% respondents reported never or rarely having problems with their advisor rarely being present in the lab (mdn = 1.0), frequently being on trips (mdn = 2.0), not in lab meetings (mdn = 1.0), not available for consultations (mdn = 2.0), not providing feedback on research (mdn = 1.0), using computer and internet for non-research purposes (mdn = 1.0), and not maintaining organized lab notes and data (mdn = 1.0).

Table 3. *Descriptive Statistics for Mentoring Problem*

	n	Mean	Median	SD	Minimum	Maximum
A. Mentoring Problems						
Advisor rarely present in lab	115	1.66	1.00	1.16	1.00	5.00
Advisor does not provide feedback on research work	115	1.96	1.00	1.34	1.00	5.00
Advisor uses computer and internet for non-research purposes	115	1.17	1.00	0.53	1.00	4.00
Advisor does not maintain organized lab notes and research data	115	1.70	1.00	1.13	1.00	5.00
Advisor disrespectful to students	115	1.77	1.00	1.34	1.00	5.00
Advisor disrespectful to others professors	115	1.69	1.00	1.27	1.00	5.00
Advisor does not give advice on what to do	115	2.15	2.00	1.36	1.00	5.00
Advisor not in good relationships with other professors	115	1.78	1.00	1.17	1.00	5.00
Advisor not in lab meetings	115	1.56	1.00	1.26	1.00	5.00
Advisor does not listen to student opinions	115	1.85	1.00	1.30	1.00	5.00
Advisor not sensitive to student's needs	115	2.18	2.00	1.20	1.00	5.00
Advisor not interested in student's well being	115	1.97	1.00	1.29	1.00	5.00
Advisor not available for consultations	115	2.05	2.00	1.27	1.00	5.00
Advisor difficult to communicate with orally and written	115	1.83	1.00	1.34	1.00	5.00
Advisor frequently on trips	115	1.97	2.00	1.07	1.00	5.00

n = Sample Size
SD = Standard Deviation

The rest of the MTP items yielded similar responses. Over 50% also reported rarely or never having problems with their advisor being disrespectful to other students (mdn = 1.0) or professors (mdn = 1.0), not being in good relationship with other professors (mdn = 1.0), not listening to students' opinions (mdn = 1.0), not being interested in students' well-being (mdn = 1.0), not giving advice on what to do (mdn = 2.0), not being sensitive to students' needs (mdn = 2.0), and being difficult to communicate with (mdn =1.0). These responses indicate that the majority of students did not report significant problems with their advisors.

4.4 Descriptive Statistics for Outcome Variables

For DTP, various items had a median value indicating an occurrence of never or rarely. For eleven DTP items, over 50% of respondents responded as never or rarely participating in research competitions (mdn = 1.0), organizing professional meetings/conferences (mdn = 1.0), presenting research at conferences (mdn = 2.0), attend trainings to enhance research skills and techniques (mdn = 2.0), take the lead in a research lab meeting (mdn = 2.0), write and submit grant proposals (mdn = 2.0), draft letters to the editor for submission of manuscripts (mdn = 1.0), draft responses to reviewers for revised manuscripts (mdn = 2.0), comment on manuscripts they are reviewing for a journal (mdn = 2.0), and write operating manuals for lab instruments and equipment (mdn = 2.0). Those items that were reported by over 50% of respondents as occurring often or very often include performing data analysis (mdn = 4.0), presenting research in departmental / lab seminars (mdn = 3.0), writing papers to submit to scholarly journals (mdn = 3.0), reviewing and critiquing leading research articles that were recently published (mdn = 3.0), commenting on reports and papers produced by the lab (mdn = 3.0), and having senior students help junior students (mdn = 3.0).

4.5 Principal Component Analysis

Doctoral Mentoring Practices – Table 4 shows the results of a principle component analysis on 15 DMP items. Following in the approach of Ynalvez et al. (2014), the PCA allowed for the identification of discrete dimensions within DMP. The dimensions uncovered by the PCA further allowed for their use in regression models to statistically examine the impact of DMP on DTP. Retained components were examined for clarity of item loading (Field, 2009). The 15 DMP items were reduced to 5 components with eigenvalues equal to or greater than 1.0 accounting for 62.21% of variance. The Kaiser-Meyer-Olkin measure of sample adequacy was calculated as .68. The loadings (a) of each item were examined for each component to determine which items composed the component. Following Ynalvez et al. (2014) items with a coefficient of an absolute value of .60 and above are retained.

Additionally, for components that match the Ynalvez et al. (2014) PCA results, similar labels were assigned as appropriate. PCm1 included item 10 (a = +.66), item 11 (a = +.75), item 12 (a = +.62), item 13 (a = +.67), and item 14 (a = +.68) which accounted for 24.81% of variance. This was labeled "mentor helps students network and job search." PCm2 included item 05 (a = +.76) and item 06 (a = +.69). PCm2 was labeled "mentor co-directs and co-authors with students" and accounted for 10.83% of variance. PCm3 comprised of item 07 (a = +.78) and item 08 (a = +.79) with 10.21% of variance. It was labeled "mentor helps student with actual bench work." Accounting for 8.39% of variance, PCm4 contains item 15 (a = +.82) and it was labeled "mentor provides research guidance." Labeled "receptive to students' personal disclosures," PCm5 had item 01 (a = +.74) and item 04 (a = +.82) with 7.97% of variance. Combined these components indicate that the respondents experienced their advisors as mentors not only in conducting research, but also in other aspects of doctoral studies and personal life.

Table 4. *Principal Component Analysis for Doctoral Mentoring Practices*

DMP Items	Principal Components[1]				
	PCm1[3]	PCm2[4]	PCm3[5]	PCm4[6]	PCm5[7]
1. Discuss career aspirations and plans of students	0.27	0.14	0.00	0.22	**0.74**
2. Monitor student's work progress	0.05	0.43	0.42	0.42	0.11
3. Discuss students concerns and problems about their research	-0.11	0.48	0.27	0.56	0.11
4. Discuss personal or family problems of students	0.11	-0.01	0.22	0.03	**0.82**
5. Co-author research paper or book chapter with students	0.22	**0.76**	0.15	-0.11	0.04
6. Co-direct research projects with students	0.13	**0.69**	-0.19	0.10	0.05
7. Analyze data and perform calculations side by side with students	0.07	0.21	**0.78**	-0.11	0.15
8. Run experiments side by side with students	0.22	-0.23	**0.79**	0.11	0.02
9. Review students for general or final exams	0.43	-0.09	0.14	0.35	-0.41
10. Help students draft job application letters	**0.66**	0.26	0.06	-0.12	0.09
11. Help students draft their curriculum vitae	**0.75**	-0.12	0.28	-0.08	0.13
12. Help students prepare for a job talk or presentation	**0.62**	-0.02	0.00	0.25	0.15
13. Help students prepare for a job positions and announcements	**0.67**	0.25	0.11	0.02	0.13
14. Socialize students to member of the scientific community	**0.68**	0.21	-0.05	0.33	-0.07
15. Give feedback on student's research and performance	0.19	-0.08	-0.12	**0.82**	0.11
eigenvalue[2]	3.72	1.63	1.53	1.26	1.20
% explained	24.81	10.83	10.21	8.39	7.97
cumulative % explained	24.81	35.64	45.85	54.24	62.21

1. absolute value of coefficient of equal or greater to .60 used to identify PC labels
2. PCs with eigenvalues of 1.0 or greater are retained (Field, 2009)
3. PCm1 mentor helps students network and job search
4. PCm2 mentor co-directs and co-authors with students
5. PCm3 mentor helps student with actual bench work
6. PCm4 mentor provides research guidance
7. PCm5 mentor receptive to student’s personal disclosure

Doctoral Training Practices – Following the PCA guidelines described above, Table 5 shows the results of an analysis conducted on 17 original items related to the students' training practices during their time in the doctoral program. The PCA reduced the 17 original items to 6 components with eigenvalues greater than 1.0 accounting for a total variance of 61.68%. The Kaiser-Meyer-Olkin measure of sampling adequacy for this PCA was .74. Again, components matching Ynalvez et al. (2014) were given similar labels. PCt1 included item 09 (a = +.66), item 10 (a = +.68), item 11 (a = +.67), and item 12 (a = +.77). It accounted for 23.06% of variance and was labeled "students writes and submits manuscripts to journals." PCt2 was composed of item 07 (a = +.67) and item 08 (a = +.62) that account for 10.47% of variance. The label applied to this component was "student engages in leadership activity." PCt3 accounted for 8.28% of variance and contained item 13 (a = +.62) and item 17 (a = +.68). This component was labeled "student analyzes and learns from external sources." PCt4 included item 03 (a = +.72) and item 05 (a = +.65) accounting for 7.51% of variance. It was labeled "student organizes and competes." Composed of item 02 (a = +.64) and item 06 (a = +.80), PCt5 accounted for 6.38% of variance. This was labeled "student generates and presents findings." PCt6 was labeled "student engages in technical writing." It included item 14 (a = +.88) accounting for 5.97% of variance.

These components indicate that students not only engage in activities related to written output, they engage in leadership activities, engage in processes to learn from external sources and evaluating the quality of sources, they share findings at conferences, and engage in technical writing. A distinction is made between the two writing practices identified. Writing for journal submission is an activity that is associated with theoretical capital whereas drafting operating manuals is related with technical capital (Hong, 2008).

Table 5. *Principal Component Analysis for Doctoral Training Practices*

DTP Items	Principal Components[1]					
	PCt1[3]	PCt2[4]	PCt3[5]	PCt4[6]	PCt5[7]	PCt6[8]
1. Present research in departmental / lab seminars	0.16	0.52	0.16	0.12	0.08	-0.33
2. Present research at conferences (national, regional, international)	0.12	0.39	0.07	0.22	**0.64**	0.01
3. Participate in research competitions (national, regional, international)	-0.08	0.34	-0.18	**0.72**	0.00	-0.09
4. attend trainings to enhance research skills and techniques	0.42	-0.06	0.10	0.57	-0.05	-0.02
5. Organize professional meetings conferences	-0.02	0.02	0.30	**0.65**	0.03	0.12
6. Perform data analyzes	0.09	-0.01	0.19	-0.13	**0.80**	0.04
7. Write and submit grant proposals	0.14	**0.67**	-0.08	0.17	0.30	0.22
8. Preside or take the lead in a research lab meeting	0.23	**0.62**	0.10	0.00	0.03	0.21
9. Comment on Manuscripts you are reviewing for a Journal	**0.66**	0.18	0.33	0.06	-0.26	-0.11
10. Write Papers for Submission to Scholarly Journals	**0.68**	0.22	0.13	-0.02	0.45	-0.16
11. Draft Letters to the Editor for submission of Manuscripts	**0.67**	0.12	-0.29	0.18	0.17	0.08
12. Draft responses to reviewers for revised and resubmitted manuscripts	**0.78**	0.16	0.08	-0.04	0.14	0.14
13. Visit other laboratories to learn research skills and techniques	0.17	-0.14	**0.62**	0.34	0.09	0.22
14. Write operating manuals for lab instruments and equipment	0.05	0.21	0.13	0.05	0.04	**0.88**
15. Have senior students help junior students	-0.30	0.35	0.50	0.07	0.08	-0.14
16. Review and comment on reports and papers produced by the lab	0.11	0.59	0.56	-0.02	-0.03	0.11
17. Review and critique recently published leading research articles	0.09	0.11	**0.68**	0.01	0.19	0.02
eigenvalue[2]	3.92	1.78	1.41	1.28	1.09	1.02
% explained	23.06	10.47	8.28	7.52	6.38	5.97
cumulative % explained	23.06	33.53	41.81	49.32	55.71	61.68

1. absolute value of coefficient of equal or greater to .60 used to identify PC labels
2. PCs with eigenvalues of 1.0 or greater are retained (Field, 2009)
3. PCt1 student writes and submits manuscripts to journals
4. PCt2 student engages in leadership activity
5. PCt3 student analyzes and learns from external sources
6. PCt4 student organizes and competes
7. PCt5 student generates and presents analysis
8. PCt6 student engages in technical writing

4.6 *Developmental Networks, DMP and DTP*

This study expands on the work of Ynalvez et al. (2014) by examining quantitative data on the relationship between doctoral mentoring practices as a predictor dimension in variations in students' engagement in several training practices that make up their doctoral experience. Additionally, it expands and contributes to the literature on doctoral mentoring by incorporating a measure of the students' developmental network as a predictor of variations in their doctoral practices. What follows is the description of two regression models that incorporate DMP and developmental networks as predictor variables of doctoral training practices DTP. These models are detailed in Table 6. Model 1 included control variables and DMP components with each component of DTP as the outcome variable. Model 2 then added the developmental network variables to Model 1. Differences in the model fit and significance are reported.

For PCt1, model 1 was significant and had a goodness of fit of (R^2 = 21.0%; adj-R^2 = 12.6%). Table 6 shows that two variables emerged as significant as related to the outcome variable. Being a third or fourth year student is associated with an increased PCt1 reporting of involvement with scholarly writing and the submission process (B= .78; $p < .001$). Also, increased reporting of advisor co-authoring and co-directing projects with students is associated with increases in PCt1 (B= .24; $p < .05$). Model 2 shows that the inclusion of developmental network variables does not significantly improve the model goodness of fit (R^2 = 21.1%; adj-R^2 = 09.8%), nor does the network type show significant associations with PCt1.

For PCt2, model 1 with a goodness of fit of (R^2 = 27.7%; adj-R^2 = 20.0%) contained three significant predictor variables. A significant association is found with an increase in reported leadership activity as the age of the respondent increased (B= .16; $p < .01$). Reports of leadership activity also increased in association with greater reports of advisors helping the students network and acquire jobs (B= .26; $p < .01$). Additionally, greater participation in leadership activity is positively associated with increased reporting of advisors being receptive to students' personal disclosures about personal matters and career aspirations (B= .23; $p < .05$). As with PCt1, adding developmental network type variables to model one does not significantly improve the model and does not yield in significant variations in PCt2. Model 1 for PCt3 showed a significant goodness of fit with (R^2 = 17.2%; adj-R^2 = 08.4%). One predictor variable emerged significant in variations of PCt3. As the reporting of advisors engaging in bench work alongside students increased, increases were found in the reporting of critiquing leading research and acquiring skills from external labs (B= .28; $p < .01$). When developmental network type variables are included, the model was not significant.

For PCt4, neither model 1 nor model 2 yields a significant fit. They also did not yield any significant predictors of variations in PCt4. As such, this report moves on to the discussion of PCt5. Model 1 for PCt5 is found to be significant with a goodness of fit (R^2 = 22.5%; adj-R^2 = 14.2%). A single predictor was found to be significant. As respondents reported increased levels of advisors engaging in bench work side by side with students, there was a decrease in the reported engagement in data analysis and presenting research findings (B= -.30; $p < .01$). Model 2 with developmental network variables was not an improvement (R^2 = 23.5%; adj-R^2 = 12.6%) of model 1. None of the developmental network variables were significant in associated variations of PCt5. Neither Model 1 nor model 2 was a significant fit despite exhibiting a significant predictor variable in variations of PCt6.

With the regression model for PCt5 highlighting a negative relationship between reports of the advisor engaging in bench work side by side with students and the degree to which students generate analysis and present findings, correlates were examined for PCm3 and reported mentoring problems. The result of the principal component analysis of MTP items is located in Table 7. The procedures of the PCA for MTP followed those described for DTP and DMP. This PCA had a Kaiser-Meyer-Olkin measure of sampling adequacy of .89. It revealed three components. PCp1 included item 02 (a = +.64), item 05 (a = +.91), item 06 (a = +.79), item 07 (a = +.75), item 08 (a = +.71), item 09 (a = +.74), item 10 (a = +.79), item 11 (a = +.79), item 12 (a = +.86), item 13 (a = +.60), and item 14 (a = +.76) that accounted for 57.78% of variance. It was labeled "advisor not professionally or socially integrated in the work place." PCp2 was composed of item 03 (a = +.69) and item 04 (a = +.67) with a variance of 9.0%. This was labeled "advisor lacks work discipline." Lastly, PCp3 included item 01 (a = +.72) and item 15 (a = +.83) with 6.80% of variance. The label for this was "advisors not in spatial proximity."

A two-tailed bivariate Pearson correlation analysis was conducted to examine PCm3 as a correlate to the three emerging components of MTP. No significant correlations were found between PCm3 and either of the MTP components. The results of the correlation analysis may be found on Table 8.

Table 6. *Multiple Linear Regression Analysis*

	PCt1: student writes and submits manuscripts to journals				PCt2: student engages in leadership activity				PCt3: student analyzes and learns from external sources			
	M1		M2		M1		M2		M1		M2	
	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.
Gender is female (1=yes; 0=no)	0.378	0.216	0.370	0.222	0.233	0.213	0.231	0.218	-0.046	0.228	-0.034	0.235
Age In Years	-0.053	0.047	-0.051	0.049	0.158 **	0.046	0.160 **	0.048	-0.038	0.050	-0.040	0.051
Native To Program Country (1=yes; 0=no)	-0.353	0.204	-0.347	0.210	0.297	0.201	0.303	0.206	0.241	0.216	0.244	0.222
Is 3rd or 4th year student (1=yes; 0=no)	0.778 ***	0.207	0.780 ***	0.212	-0.071	0.203	-0.080	0.208	-0.036	0.218	-0.040	0.224
Is Married (1=yes; 0=no)	0.144	0.269	0.149	0.280	0.133	0.265	0.165	0.275	0.172	0.284	0.172	0.296
PCm1 mentor helps students network and job search	0.100	0.098	0.094	0.107	0.260 **	0.097	0.238 *	0.105	0.012	0.104	0.023	0.113
PCm2 mentor co-directs and co-authors with students	0.239 *	0.093	0.246 *	0.099	0.150	0.091	0.167	0.097	0.169	0.098	0.167	0.104
PCm3 mentor helps student with actual bench work	0.106	0.095	0.110	0.099	-0.060	0.094	-0.060	0.098	0.280 **	0.101	0.273 *	0.105
PCm4 mentor provides research guidance	0.034	0.095	0.040	0.098	0.122	0.094	0.131	0.096	0.172	0.100	0.168	0.104
PCm5 mentor receptive to student's personal disclosure	-0.073	0.092	-0.075	0.094	0.233 *	0.090	0.224 *	0.092	0.066	0.097	0.066	0.099
Traditional Network (1=traditional; 0=receptive)			0.088	0.257			0.178	0.252			-0.067	0.271
Opportunistic Network (1=opportunistic; 0=receptive)			-0.015	0.327			0.122	0.321			-0.001	0.345
Entrepreneurial Network (1=entrepreneurial; 0=receptive)			0.038	0.302			0.076	0.296			-0.104	0.319
n = 105												
R^2		0.210		0.211		0.277		0.281		0.172		0.173
Adj. R^2		0.126		0.098		0.200		0.179		0.084		0.055
Sig		0.011		0.044		0.000		0.003		0.047		0.145

a B is the unstandardized coefficient

b Standard alpha levels <.05* <.01** <.001***

c Cases with missing data were excluded from analysis

	PCt4: student organizes and competes				PCt5: student generates and presents analysis				PCt6: student engages in technical writing			
	M1		M2		M1		M2		M1		M2	
	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.	B[a]	S.E.
Gender is female (1=yes; 0=no)	-0.269	0.234	-0.329	0.236	-0.259	0.222	-0.280	0.227	-0.008	0.225	-0.013	0.230
Age In Years	-0.017	0.051	-0.009	0.052	0.025	0.048	0.033	0.050	-0.024	0.049	-0.028	0.050
Native To Program Country (1=yes; 0=no)	-0.085	0.222	-0.128	0.223	0.332	0.210	0.360	0.215	0.157	0.213	0.114	0.217
Is 3rd or 4th year student (1=yes; 0=no)	0.363	0.224	0.418	0.225	-0.018	0.212	-0.002	0.216	-0.140	0.215	-0.140	0.219
Is Married (1=yes; 0=no)	-0.270	0.292	-0.372	0.297	-0.353	0.277	-0.379	0.286	0.716 *	0.280	0.720 *	0.289
PCm1 mentor helps students network and job search	0.195	0.107	0.197	0.114	0.080	0.101	0.103	0.110	0.203	0.102	0.167	0.111
PCm2 mentor co-directs and co-authors with students	-0.094	0.101	-0.146	0.105	0.084	0.095	0.089	0.101	-0.091	0.097	-0.107	0.102
PCm3 mentor helps student with actual bench work	0.149	0.103	0.192	0.106	-0.301 **	0.098	-0.293 **	0.102	-0.118	0.099	-0.109	0.103
PCm4 mentor provides research guidance	0.047	0.103	0.040	0.104	0.175	0.098	0.187	0.100	-0.115	0.099	-0.125	0.101
PCm5 mentor receptive to student's personal disclosure	-0.021	0.099	0.004	0.100	-0.120	0.094	-0.120	0.096	0.051	0.095	0.057	0.097
Traditional Network (1=traditional; 0=receptive)			-0.191	0.273			0.075	0.262			-0.051	0.265
Opportunistic Network (1=opportunistic; 0=receptive)			-0.345	0.347			-0.300	0.334			0.235	0.337
Entrepreneurial Network (1=entrepreneurial; 0=receptive)			0.417	0.321			-0.110	0.308			0.328	0.311
n = 105												
R^2		0.121		0.158		0.225		0.235		0.134		0.150
Adj. R^2		0.027		0.038		0.142		0.126		0.042		0.029
Sig		0.247		0.220		0.006		0.018		0.168		0.265

a B is the unstandardized coefficient

b Standard alpha levels *, **, ***: <.05 <.01 <.001

c Cases with missing data were excluded from analysis

Table 7. *Principal Component Analysis for Mentoring Problems*

MTP Items	Principal Components[1]		
	PCp1[3]	PCp2[4]	PCp3[5]
1. Rarely present in lab	0.404	-0.228	**0.724**
2. Advisor does not provide feedback on research work	**0.635**	0.457	0.341
3. Advisor uses computer and internet for non-research purposes	0.172	**0.688**	-0.067
4. Advisor does not maintain organized lab notes and research data	0.352	**0.674**	0.254
5. Advisor disrespectful to students	**0.913**	0.176	0.012
6. Advisor disrespectful to others professors	**0.789**	0.247	-0.048
7. Advisor does not give advice on what to do	**0.746**	0.366	0.290
8. Advisor not in good relationships with other professors	**0.706**	0.227	0.057
9. Advisor not in lab meetings	**0.739**	0.388	0.099
10. Advisor does not listen to student opinions	**0.790**	0.263	0.130
11. Advisor not sensitive to student's needs	**0.794**	0.188	0.206
12. Advisor not interested in student's well being	**0.859**	-0.067	0.219
13. Advisor not available for consultations	**0.601**	0.207	0.479
14. Advisor difficult to communicate with orally and written	**0.758**	0.404	0.139
15. Advisor frequently on trips	-0.110	0.217	**0.826**
eigenvalue[2]	8.17	1.35	1.02
% explained	54.48	9.00	6.80
cumulative % explained	54.48	63.48	70.28

1. absolute value of coefficient of equal or greater to .60 used to identify PC labels
2. PCs with eigen values of 1.0 or greater are retained (Field, 2009)
3. PCp1 advisor not professionally or socially integrated in the work place
4. PCp2 advisor lacks work discipline
5. PCp3 advisor not in spatial proximity

Table 8. *Bi-variate Pearson Correlation Analysis of MTP and DMP*

		PCm3	PCp1	PCp2	PCp3
PCm3	Pearson Correlation	1	.047	-.048	-.160
	Sig. (2-tailed)		.628	.621	.095
	N	110	110	110	110
PCp1	Pearson Correlation	.047	1	.000	.000
	Sig. (2-tailed)	.628		1.00	1.00
	N	110	115	115	115
PCp2	Pearson Correlation	-.048	.000	1	.000
	Sig. (2-tailed)	.621	1.00		1.00
	N	110	115	115	115
PCp3	Pearson Correlation	-.160	.000	.000	1
	Sig. (2-tailed)	.095	1.00	1.00	
	N	110	115	115	115

PCm3 mentor helps student with actual bench work

PCp1 advisor not professionally or socially integrated in the work place

PCp2 advisor lacks work discipline

PCp3 advisor not in spatial proximity

Standard alpha levels *, **, ***: <.05 <.01 <.001

5. DISCUSSION

The results detailed and presented above provide insight about students' engagement in doctoral training activities and with doctoral advisors' mentoring practices, both from the perspective of students. The essential findings of this analysis are that while advisors do have an effect on doctoral training practices, the effect of developmental networks is not supported.

The evaluation of the advisor and developmental network as separate predictors is predicated on the understanding that the mentor is an essential source of socialization and learning for students in doctoral training programs (Campbell, 2003; Lechuga, 2011). Indeed, the results of model 1 partially support H1. The reporting of their advisor as co-directing and co-authoring with students, helping students in job searching, being receptive to self-disclosures, and helping students with bench work was positively associated with enhanced engagement in writing and submitting to journals, leadership activity, analyzing and learning from external sources, and performing analysis and presenting findings at conferences. It is worth observing that three of the significant predictor components are composed of items that were reported as never or rarely occurring by over half of respondents. Though not all training practices were modified by mentoring practices, the results provide perspective on the apparent significance of having an advisor that demonstrates mentoring practices that do not simply focus on conducting research. The significance of the developmental network is less apparent.

Developmental network theory is a fertile source of inquiry as its potential application to various spheres of professional life has only recently been a topic of discussion throughout the literature on mentoring (Molloy, 2005) and the literature on doctoral education (Baker and Lattuca, 2010). The methodology described in this study to determine the developmental network type of each respondent is novel in that as of this writing an empirical application of the developmental network typology has yet to be published. This is still the case since Molloy's 2005 review of the literature on developmental networks.

It is apparent that the majority of students in this study reported weak ties to and the low sectoral diversity of alters. Though it may be intuitive to assume that the traditional developmental network type would be the dominant case for doctoral students with potentially strong ties to alters within academia, results indicate that majority– well over half –of students report having a receptive developmental network type. Baker and Lattuca's (2010) theoretical understanding of the impact of developmental networks on doctoral students' development suggest that the receptive developmental network type is prone to producing the least amount of career and psychosocial support. Thus, it was hypothesized that students with either a traditional, opportunistic, or entrepreneurial developmental network type would exhibit enhanced and/or diverse engagement in doctoral training activities as compared to students with a receptive network. The results uncovered through regression analyses contribute to this scholarly discussion.

Model 2 incorporated developmental network type as a predictor– previously omitted in model 1 –in order to examine its impact as an element responsible for variations in doctoral training practices. This study was unable to identify a significant difference in the explanatory power of a model that incorporated the developmental network type, nor did it uncover a significant variation of training practices for students with either a traditional, opportunistic, or entrepreneurial developmental network type. H2 was not supported by these empirical findings.

A major consideration linked to this finding is the methodological process for identifying respondents' developmental network type. Higgins and Kram's specification of the developmental network typology provides guidance on the characteristics that make up each network type. However, they did not detail any specific empirical measures that could be used to link mechanisms and outcomes. The measure of alters' sectoral diversity is straightforward and allows the identification of alters located in various sectors. Conversely, tie strength is a less specific dimension of the developmental network typology. Its measure can include the occurrence of communication, emotions towards, and mutuality of network relationships (Higgins and Kram, 2001). Of these aspects, this study only captured measures of communication at the point of data collection, and thus focused on the aspect of communication as a measure of tie strength. Specifically, it incorporated a measure of communication duration as an alternative to frequency of communication, which may cause issues in acquiring an accurate and full content valid measure of tie strength among colleagues (Marsden and Campbell, 1984). Overall, this study argued the validity of Higgins and Kram's prescription as applicable to doctoral science training. However, further inquiry is necessary to determine if the measures of the developmental network type are the limiting factor in supporting the perspective that developmental networks influence doctoral training practices.

The age of the mentor and if students' were in their third and fourth year of the program were also associated with enhanced training practices. Older students reported increased participation in leadership activities, and students in their third and fourth year reported greater participation in writing and submitting to scholarly journals. These findings are aligned with the socialization process of graduate students that sees seasoned students as exiting a phase of competency development to a phase completing projects and socialization as a professional (Tinto, 1993).

Overall, it is found that doctoral students in science training programs in East Asia report varying degrees of engagement in all training practices considered. For instance, it was found that the majority of students reported rarely or never engaging in eleven different training practices that involve leadership skills or interacting with the professional community outside of the lab. It should be noted that with the exception of organizing professional meetings and conferences, respondents reported engaging in each activity at all levels captured by the questionnaire; however, performing data analysis emerged as the activity with the greatest frequency of engagement by the majority of respondents. A majority reported engaging frequently in activities that can be constrained to their lab environment and with individuals associated with their department or lab. These findings suggest that many students do not frequently attain skills outside of the lab, whether through trainings or visiting other labs, or engage in the social aspects of knowledge dissemination. While this retraction from external engagement and shared knowledge may be a result of being socialized by a training system that arguably produces activity that favors the avoidance of external connections, further information would be necessary to determine if the results of this study are in part due to the influence of academic capitalism (Mendoza, 2007) or if other socialization mechanisms are responsible.

A majority of students also reported that their advisors frequently includes students in directing and authoring research as well as monitoring and addressing students' issues on research. These observations by students suggest a dominance of mentoring activities that favor research support in the form of evaluative guidance. In terms of career and psychosocial support, the majority of students saw advisors as providing challenging assignments via co-directing and co-authoring on projects and support on those assignments, but did not observe career sponsorship or emotional support as students transition in and out of life as a doctoral student. The prevalence of research related training and mentoring activities is of relevance in the discussion of developing scientific occupational competencies as it is recognized that the emphasis on traditional research activity may be limiting graduate students in their preparation for the variety of employment opportunities outside of academia (Campbell et al., 2005; Enders and De Weert, 2004; Wiesel and Banda, 2002).

In the case of students who reported engaging less with data analysis and presentation of findings in association with increased reporting of advisors doing bench work with students, it is clear that more information is needed to uncover the source of students engaging less in certain practices if it is not related to mentoring problems. This finding precludes the confirmation of H3. Overall, these results support that the advisor has some impact on students' training practices, whereas the impact of the developmental network remains inconclusive.

6. CONCLUSIONS

This study was aimed at investigating doctoral science training experience with the intention of answering the question whether doctoral mentoring practices and doctoral students' developmental network configure doctoral training practices. This was accomplished through a quantitative analysis of survey data that incorporated a novel application of the developmental network typology, and simultaneously proposed a protocol to measure such networks. While evidence regarding the influence of mentoring practices was arrived at, the impact of traditional, opportunistic, and entrepreneurial developmental network types on doctoral training practices was not supported by empirical data.

This study is an attempt to develop a novel and empirical measure of the developmental network type. A methodology was developed and utilized to apply the developmental network typology in a quantitative analysis of the doctoral training experience. This process, outlined in this study, is relevant not only to the networks of doctoral students, but also to any future application of the developmental network typology that seeks to advance the knowledge of social networks. The contribution to the advancement of the theory of developmental networks provides a foundation for additional research that has the potential to validate and refine the concept of the developmental network.

Also, the significant results of this study highlight the importance of the socialization process by which students develop their competencies through varied training practices. Specifically, it underscores that advisors are a critical component of socialization to the scientific life in and outside of academia. Advisors' practices should be considered if the expectation is that students will learn to be leaders and managers in the workforce as a part of their doctoral training. The lack of support for the impact of developmental networks, however, indicates that further research on socialization and doctoral training is warranted.

The preceding points indicate that advance scientific training must be examined and configured to ensure that students are engaging in training practices that are preparing them to fill occupations after graduation. Institutions of higher education need consider if their students are engaging in practices that develop leadership, management, and technical skills. Such skills will be of use in positions found in industry, government, and academia. Through the monitoring of program outcomes, adjustments and initiatives may be directed at ensuring that students enhance and diversify their engagement in doctoral training practices.

This study had some limitations and weaknesses related to the implementation of the developmental network typology. The process of this study was influenced by the time and budgetary constraints that placed limits on the scope and complexity of the study. This limitation constrained the sample size. It is recognized that the influence of developmental networks may be significant in larger samples whereas no influence was found in this smaller sample. Yet another consideration is the focus on a singular measure of tie strength and of network range. As an aspect of the developmental network typology, tie strength is a concept with multiple dimensions which could be measured by duration, frequency, and timing of interaction; and to have these same measures combined by estimating and using appropriate statistical weights. A similar argument is forwarded and an equally similar strategy is recommended in regards to conceptualizing and measuring network range.

It is recognized that these limitations and weaknesses may have attenuated the argument that developmental networks are influential. Nonetheless, the results of this study provide the foundation for expanding and refining the process of studying doctoral training experience through a developmental network framework. Given these considerations, further study of advisors and developmental networks in association with doctoral training is recommended. Future investigations may uncover the nuances that promote the development of a professional with the scientific occupational competencies needed to join a work force with increasingly diverse needs.

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APPENDIX A

DOCTORAL TRANING 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 you done the following:

		N	R	O	VO
1	Present research in departmental / lab seminars	1	2	3	4
2	Present research at conferences (national, regional, international)	1	2	3	4
3	Participate in research competitions (national, regional, international)	1	2	3	4
4	Attend trainings to enhance research skills and techniques	1	2	3	4
5	Organize professional meetings conferences	1	2	3	4
6	Perform data analysis	1	2	3	4
7	Write and submit grant proposals	1	2	3	4
8	Preside or take the lead in a research lab meeting	1	2	3	4
9	Comment on manuscripts you are reviewing for a journal	1	2	3	4
10	Write papers for submission to scholarly journals	1	2	3	4
11	Draft responses to reviewers for revised and resubmitted manuscripts	1	2	3	4
12	Draft letters to the editor for submission of manuscripts	1	2	3	4
13	Visit other laboratories to learn research skills and techniques	1	2	3	4
14	Write operating manuals for lab instruments and equipment	1	2	3	4
15	Have senior students help junior students	1	2	3	4
16	Review and comment on reports and papers produced by the lab	1	2	3	4
17	Review and critique recently published leading research articles	1	2	3	4

APPENDIX B

DOCTORAL MENTORING PRACTICES

Rate your doctoral advisor in terms of the frequency of the following practices using the following scale: 1 = never, 2 = rarely, 3 = often, 4 = very often.

		N	R	O	VO
1	Advisor discusses career aspirations and plans with students	1	2	3	4
2	Advisor monitors students' work progress	1	2	3	4
3	Advisor discusses students' concerns and problems about research	1	2	3	4
4	Advisor discusses personal and/or family problems with students	1	2	3	4
5	Advisor co-directs research project with students	1	2	3	4
6	Advisor co-authors research paper or book chapter with students	1	2	3	4
7	Advisor analyzes data and performs calculations side by side with students	1	2	3	4
8	Advisor runs experiments side by side with students	1	2	3	4
9	Advisor reviews students for general or final exams	1	2	3	4
10	Advisor helps students draft job application letters	1	2	3	4
11	Advisor helps students draft their curriculum vitae	1	2	3	4
12	Advisor helps students prepare for job talk or presentation	1	2	3	4
13	Advisor helps students search for job positions and announcements	1	2	3	4
14	Advisor socializes students to members of the professional community	1	2	3	4
15	Advisor gives feedback on students' research performance	1	2	3	4

APPENDIX C

MENTORING PROBLEMS

The following is a list of problems that doctoral students say they experience when working with their doctoral advisors. Based on your experience, is this a problem for you? Please evaluate each of these problem areas using the following scale: 1 = not a problem, 5 = major problem

1	Advisor rarely present in the lab	1	2	3	4	5
2	Advisor does not provide feedback on research work	1	2	3	4	5
3	Advisor uses computer and internet for non-research purposes	1	2	3	4	5
4	Advisor not maintaining organized laboratory notes and research data	1	2	3	4	5
5	Advisor disrespectful to students	1	2	3	4	5
6	Advisor disrespectful to other professors	1	2	3	4	5
7	Advisor does not give advice on what to do	1	2	3	4	5
8	Advisor not in good relationship with other professors	1	2	3	4	5
9	Advisor not in lab meetings	1	2	3	4	5
10	Advisor does not listen to students' opinions	1	2	3	4	5
11	Advisor not sensitive to students' needs	1	2	3	4	5
12	Advisor not interested in students' well-being	1	2	3	4	5
13	Advisor not available for consultation	1	2	3	4	5
14	Advisor difficult to communicate with orally and written	1	2	3	4	5
15	Advisor frequently on trips	1	2	3	4	5

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Survey Manager – Texas A&M International University NSF SciSIP Grant 2013

Coordinate and collect survey data in Singapore for the Department of Social Sciences.

Presentations

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