

SOCIALIZATION EXPERIENCES OF STEM INTERNATIONAL GRADUATE
STUDENTS AT AMERICAN PUBLIC RESEARCH UNIVERSITIES: A
MULTIVARIATE ANALYSIS

by

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DEDICATION

I dedicate this dissertation to several people who have influenced the course of this process and in turn my life. I am indebted to Drs. Kelly Ward and Betsy Palmer and their generous, rigorous, yet kind mentoring. May their influential light continue to shine on in all of us who were blessed to know them. Betsy and Kelly advised several of us over the years with words of wisdom that remain inspiring. They demonstrated by example, to live in the present moment ... that a done dissertation is a good dissertation ... the value of friendship ... walk ... read for fun ... travel often and regularly ... strive for life-work balance ... grow where planted ... have babies ... not have babies ... health comes first ... love our partners... love ourselves ... be kind ... laugh more ... remain curious ... there is no shortage of ideas ... stay on course ... make connections ... be humble ... reflexive ... accept our limitations ... yet break through perceived barriers ... be the first ... be noble... mentor others ... and be sure to invite others to the party.

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May the road rise to meet you...

May the road rise to meet you,
may the wind be ever at your back.
May the sun shine warm upon your face,
and the rains fall soft upon your fields.
And until we meet again,
may God hold you in the palm of his hand.

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TABLE OF CONTENTS

1. INTRODUCTION	1
Background	2
Contextualizing the Study	7
Socialization.....	9
Statement of the Problem.....	12
Purpose of the Study	15
Research Questions	16
Theoretical Framework.....	17
The Significance of the Study.....	19
Definition of Terms.....	20
International Graduate Student	21
Socialization.....	21
Intercultural Relevancy in STEM	21
Social Interaction	22
Cultural Congruity	22
Identity Prominence	23
The Carnegie Classification of Institutions.....	23
Assumptions.....	24
Limitations	24
Delimitations	26
Chapter One Summary.....	26
2. LITERATURE REVIEW	28
Introduction.....	28
Historical Overview	30
STEM International Graduate Students: Trends in the U.S. Context.....	32
Enrollment in the United States	33
Competing Global Markets and Revenue Decline.....	35
Pivotal Events and Policies	36
Theoretical Foundations	37
Socialization Theory	38
Cultural Perspectives and Socialization.....	40
Intercultural Relevancy	43
Social Interactions.....	47
Mentor's Cultural Support	51
Mentor's Academic Support	52
Peer Interactions	53
Cultural Congruity	55
Identity	55

TABLE OF CONTENTS CONTINUED

Professional Identity	59
Social Identity	60
Contextual Factors	61
Chapter Two Summary: Literature Review	63
 3. METHODOLOGY	 65
Introduction.....	65
Research Design.....	68
Research Questions.....	69
Role of the Researcher	69
Sampling Approach	73
Population	73
Characteristics of Participants.....	77
Instrument	82
Outcome Variables.....	87
Intercultural Relevancy in STEM	87
Cultural Integrity in STEM.....	87
Connections with Cultural Representatives	88
Explanatory Variables.....	91
Social Interactions.....	91
Mentor's Cultural Support	91
Mentor's Academic Support.....	91
Peer Interactions.....	92
Cultural Congruity	94
Identity Prominence	96
Professional Identity	96
Social Identity	96
Data Analysis	98
Data Preparation and Preliminary Analysis	98
Factor Analysis	98
Analytic Plan: Ordinary Least Squares Regression	105
Series 1: Cultural Integrity in STEM.....	106
Series 2: Connections with Cultural Representatives	107
Assumptions of Ordinary Least Squares Regression.....	108
Validity of Design.....	109
External	109
Internal	110
Chapter Three Summary: Methodology	112

TABLE OF CONTENTS CONTINUED

4. RESULTS	114
Introduction.....	114
Descriptive Statistics of the Study Sample and Foci Variables.....	114
Results Overview	119
Research Questions: Cultural Integrity in STEM	119
Research Questions: Connections with Cultural Representatives	120
Model Series 1: OLS Regression Models for the Dependent Variable:	
Cultural Integrity in STEM	122
Research Question 1: Relationship between Social Interactions and Cultural Integrity in STEM.....	122
Research Question 2: Relationship between Cultural Congruity and Cultural Integrity in STEM.....	128
Research Question 3: Relationship between Identity Prominence and Cultural Integrity in STEM.....	131
Model Series 2: OLS Regression Models for the Dependent Variable:	
Connections with Cultural Representatives	134
Research Question 4: Relationship between Social Interactions and Connections with Cultural Representatives	135
Research Question 5: Relationship between Cultural Congruity and Connections with Cultural Representatives	141
Research Question 6: Relationship between Identity Prominence and Connections with Cultural Representatives	145
Chapter Four Summary: Results.....	148
5. CONCLUSIONS.....	150
Introduction.....	150
Overview	151
Methodology	153
Discussion of the Results.....	155
Dependent Variable: Cultural Integrity in STEM.....	156
Research Question 1: Relationship between Social Interactions and Cultural Integrity in STEM.....	157
Research Question 2: Relationship between Cultural Congruity and Cultural Integrity in STEM	160
Research Question 3: Relationship between Identity and Cultural Integrity in STEM	161
Outcome Variable One Demographic and Background Characteristics.....	162
Dependent Variable: Connections with Cultural Representatives.....	164

TABLE OF CONTENTS CONTINUED

Research Question 4: Relationship between Social Interactions and Connections with Cultural Representatives	165
Research Question 5: Relationship between Cultural Congruity and Connections with Cultural Representatives	167
Research Question 6: Relationship between Identity and Connections with Cultural Representatives	168
Outcome Variable Two Demographic and Background Characteristics	169
Summary of Results	171
Limitations	175
Implications for Research Methodology	178
Future Research Considerations	180
Recommendations for Policy and Practice	183
Closing Remarks	186
REFERENCES CITED	188
APPENDICES	209
APPENDIX A: NSF and NIH Disclaimers	210
APPENDIX B: The Pacific Northwest Circle of Success: Mentoring Opportunities in STEM Award Abstract #143291	212
APPENDIX C: PNW-COSMOS Graduate Student Experiences Survey	215
APPENDIX D: NSF STEM Classification by Biglan's Four Disciplinary Typologies	231
APPENDIX E: Correlation Matrices of Study Variables	235

LIST OF TABLES

Table	Page
3.1 Survey response rate by institution and research university comparison of institution population, 2015: Total numbers of full-time graduate students and International graduate students in STEM, and Health.....	76
3.2 Characteristics of International Graduate Student Participants ($n = 953$)	79
3.3 Institutional context, number and percentage of international graduate students by Basic Carnegie Classification e	80
3.4 Participating research universities' characteristics and classifications.	81
3.5 Demographics characteristics: A list of the control study variables and their levels of measurement	84
3.6 Background and institutional characteristics: A list of the control variables and their levels of measurement	86
3.7 Outcome Variables and their levels of their measurement	90
3.8 Social interactions: A list of the study variables and their levels of measurement	93
3.9 Cultural congruity: A list of the study variables and their levels of measurement	95
3.10 Identity prominence: A list of the study variables and their levels of measurement.	97
3.11 Factor Analysis Intercultural Relevancy in STEM Scale ($\alpha = .76$).	100
3.12 Factor Analysis Mentor Interactions Scale ($\alpha = .93$).	101
3.13 Factor Analysis Identity Prominence Scale ($\alpha = .79$)	102

LIST OF TABLES – CONTINUED

Table	Page
3.14 PNW-COSMOS Graduate Student Experiences survey sample comparison of internal reliability coefficients (Cronbach's alphas).....	104
4.1 Means and Standard Deviations of Study Variables (n = 953).....	116
4.2 Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Mentor's Support (n = 953).....	125
4.3 Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Peer Interactions (n = 953)	127
4.4 Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Cultural Congruity (n = 953).....	130
4.5 Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Identity Prominence (n = 953).....	133
4.6 Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Mentor's Support (n = 953)	137
4.7 Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Peer Interactions (n = 953)	140
4.8 Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Cultural Congruity (n = 953).....	144
4.9 Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Identity Prominence (n = 953).....	147

LIST OF TABLES — CONTINUED

Table	Page
5.1 Intercultural socialization practices for professionals and institutions to support international graduate students	185

ABSTRACT

STEM international graduate students encounter unique challenges at American public research universities. One of these challenges relates to the cultural isolation international graduate students face as they traverse American higher education (Lee & Rice, 2007). Factors found influential to international students' persistence include the faculty advisor and advisee relationship (Rice et al., 2009), peer interactions (Rose-Redwood & Rose-Redwood, 2013), and identity formation (Gomes & Tran, 2017; Phelps, 2016). As a multiple regression study, the research questions were designed to determine the extent international graduate students' faculty mentor and peer relationships, cultural congruity, and identity prominence influence intercultural relevancy as parts of the socialization process (Kuh & Love, 2001; Museus & Quaye, 2009). Over a thousand international graduate students from 12 research universities participated in the Graduate Student Experiences survey; an NSF funded Alliances for Graduate Education and the Professoriate project. The final analytical sample ($n = 953$) was analyzed using ordinary least squares regression. The first set of results indicated that mentor's cultural support, peer interactions, social and professional identity prominence had significant positive effects on international graduate students' cultural integrity in STEM. The second set of models indicated that mentors' cultural support, peer interactions, cultural congruity, social and professional identity prominence were positively associated with levels of international graduate students' connections with cultural representatives. These findings suggest faculty mentor's cultural support, peer interactions, social and professional identity are important for developing intercultural relevancy within international graduate students at American public research universities. More importantly, students' perceptions of intercultural relevancy differ across groups. This study contributes to the research on graduate education in several ways. First this study provides a quantitative look at international graduates' experiences in the U.S. The contribution of this study is the use of data from a nationally administered graduate student experiences survey at 12 institutions that included newly developed measures of intercultural relevancy in STEM, identity prominence, and mentor interaction. Measures of intercultural effort provide another way to interpret graduate student socialization. The empirical findings add to the growing body of literature on graduate education, international students.

CHAPTER ONE

INTRODUCTION

The United States has long been a leading destination of learning for international graduate (IG) students, especially in the competitive fields of science, technology, engineering, and mathematics (STEM). International graduate students often come from academic and social cultures that are different from what they encounter during their graduate studies in the United States (Erichsen & Bolliger, 2011; McLachlan & Justice, 2009; Todoran, 2018). These cultural differences present some common challenges in the socialization of international graduate students over the course of their graduate training. One of the challenges faced in graduate school pertains to social interaction, i.e., cultivating and sustaining positive relationships with their advisor and peers (Crede & Borrego, 2014; Le & Gardner, 2010). Another challenge concerns international graduate students' perceived value of their culture within a different environment and cultural setting, along with their transitory and ongoing needs as sojourners studying in the U.S. The third challenge, an underexplored area of the literature, is related to the role that identity plays in the socialization of international graduate students in STEM graduate programs in the U.S. With these three challenges in mind, the next section focuses on international graduate students' contributions to American higher education. A discussion follows on some of the crucial social, political, and economic implications of international student participation and the recent decline in applications from

internationals and the subsequent decrease in numbers admitted to U.S. graduate schools in 2017 and 2018.

Background

Over the last 40 years, American Higher Education experienced a massive influx of international graduate students (Gumport, 2017; LaPidus, 2001; Posselt, 2016). Moreover, since the 1970s, a considerable number of international graduate students enrolled in reputable research universities in the U.S. for master's and doctoral programs that were primarily in STEM (Choudaha, 2017). By the 1990s, higher education became a more valuable resource globally because of the need for more highly skilled workers due to the advent of information and communication technologies (Choudaha, 2017). As the value of postsecondary education and the need for highly skilled workers increased within other nations, graduate education in the United States became a popular destination for foreign nationals to come who sought economic and social advancement (Gopal, 2016; Han & Appelbaum, 2016; National Research Council, 2005). According to the Open Doors report, the total overall enrollment of international graduate students reached 391,124 and represented 194 countries in the 2016/2017 academic year (Institute of International Education, 2017). By educational level, there were 237,679 international graduate students enrolled in master's degree programs, and 124,705 enrolled at the doctoral level (Institute of International Education, 2017). In STEM, international graduate students represent the most significant percentage of first-time graduate students

in mathematics and computer sciences (60.7%) followed closely by engineering (55.7%) (Okahona, 2017).

International graduate students have made social, political, and economic contributions to the U.S. and its' institutions. National and international graduate students benefit from their continued involvement in graduate education. Social good, prestige, and economic growth are just some of the outcomes of this mutually beneficial relationship. International graduate students' long-term participation in higher education has brought about social good that delivered long-lasting benefits to the larger society (Brauner-Bevis & Lucas, 2007; National Research Council, 2005). For example, the presence and participation of international graduate students in U.S. higher education enrich the learning of faculty and students. International graduate students bring intellectual and cultural diversity to research universities. These attributes promote the importance of U.S. relations around the world. A common trend in higher education is the inclusion of global citizenship as an outcome of an institutions' internationalization goals (Fischer & Green, 2018; Green, 2012). Research universities recruitment of international graduate students and their presence and participation in U.S. higher education helps to meet those goals.

According to international academic rankings of world-class universities, U.S. research universities lead the list of the top 50 institutions (Hazelkorn, 2015; Shanghai Consultancy, 2018). This ranking is in part because the U.S. system of higher education is considered one of the of the best systems in the world for its research innovations and varied institutional types (Golde, 2006). Research universities in the U.S. are known to

attract the best and the brightest students from around the world. The research system has historically collaborated with the federal government for research support (Choudaha, 2017; Gumport, 2017; National Research Council, 1996). International graduate students apply to schools and come to the U.S. for many reasons, such as, the brand, reputation, and prestige of an institution that they offer to meet their career needs or very often as representatives of their country (Institute of International Education, 2017; Taylor & Cantwell, 2015).

The third contribution relates to the economic growth internationalization spurs. According to the U.S. Department of Commerce, in 2016 international students financially contributed \$39.4 billion to the U.S. economy, this figure includes undergraduate international student contributions (Institute of International Education, 2017). Colleges and universities in the U.S. profit greatly from international graduate students' participation in higher education. In the next section, I describe the current state of understanding related to the international graduate student participation in STEM and then explain some of the unique challenges they encounter in the U.S. that are the focus of the study.

This study is situated in the context of STEM because international graduate students make up the highest percentage of students enrolled in STEM fields in the United States. For example, the highest population of graduate students in engineering and computer science are full time internationals (IIE, 2017). More specifically, the Survey of Earned Doctorates annual report indicated that students who self-report as international make up the largest group in STEM degree graduate programs: electrical

engineering and petroleum engineering (81%), computer science (79%), industrial engineering (75%), statistics (69%), mechanical engineering and economics, statistics (63%), civil engineering (59%) and chemical engineering (57%) (Anderson, 2017; National Foundation for American Policy, 2017; National Science Board, 2016; NSF, 2016).

International graduate students are a distinctive population who can be considered self-determining agents with specialized needs. They often traverse multiple global fields (Marginson, 2013; Phelps, 2016; Szelényi & Rhoads, 2007). International graduate students come to the U.S. from a range of countries. The highest percentage of international graduate applications continue to come from China (38%) and India (30%). Not surprisingly, first-time international graduate enrollment percentage is highest for China (36%) and India (27%) (Okahana, 2017).

In the U.S., international graduate students hold the fastest time to degree and highest completion rates across groups and disciplines (Council of Graduate Schools, 2008; Curtin et al., 2013). Many reasons exist as to why international graduate students tend to complete graduate school at higher rates than domestic students (Ampaw & Jaeger, 2012). The higher education literature refers to academic, financial, and institutional aspects to explain their faster time to degree (Ampaw & Jaeger, 2012; Rice et al., 2009).

One academic reason includes preparedness for graduate study. Depending on their nation of origin, often international graduate students come to the U.S. with rigorous training in their discipline. Entry into STEM in some countries is extremely competitive,

and students with STEM talent are identified early in their schooling. International graduate students have financial responsibilities that can also be taxing. They usually incur higher tuition costs than domestic students and work opportunities must mind visa-related restrictions (Rice et al., 2009; Zhao, Golde, & McCormick, 2007). Another aspect is how institutions implement graduate student enrollment policies. For example, a policy that makes full-time continuous enrollment mandatory deters international graduate students from taking breaks in their study which then influences their time to degree and socialization experiences (Ampaw & Jaeger, 2012). These are just a few of the reasons that are found to influence international graduate students' faster time to degree and higher completion rates than domestic students (Crede & Borrego, 2014).

International graduate students may experience social isolation that come from extended stays abroad, being away from family and community, as well as linguistic isolation. English is the traditional language of the global scientific community, yet it is the second language or third language of many international graduate students (Andrade, 2006b; Sawir, Marginson, Forbes-Mewett, Nyland, & Ramia, 2012). Yet, there is a body of research that is bringing to light other aspects of their experiences such as the social isolation that international graduate students encounter in the U.S. For example, social isolation may result in feelings of otherness, mobility challenges, professional preparedness, and employment readiness as they enter the job market (Choudaha, 2017; Daniel, 2007; Glass, 2012). One example of isolation is when students need to navigate the visa requirement policies and procedures and the sudden placement of restrictions on travel between the U.S. and their home country. This isolation is associated with both

social and cultural aspects of being an international student in the U.S. Therefore, the theoretical underpinnings of this study aim to understand the socialization and intercultural relevancy that international graduate students have at American public research universities.

International Graduate students intercultural and socialization experiences are delineated by their experiences with social interaction, identity formation, and intercultural relevancy. Social interaction is comprised of peer and faculty interactions and students' perceptions of their identity. Intercultural relevancy is defined by the extent to which international graduate students perceive their culture is valued by others, the campus, and the STEM environment. In the next section, I provide some contextual information about the three core constructs of the study: social interaction, culture, and identity.

Contextualizing the Study

While the overall number of research studies on international graduate students' experiences at American institutions is considered thin when compared to research in their experiences in other nations, the latest interest in their experiences in the U.S. is reflected in the rise in publications on this topic (Crede & Borrego, 2014; George, Saclarides, & Lubienski, 2018; E. Kim, 2018; Robinson-Pant & Magyar, 2018; Salfi, 2013; Terrazas-Carrillo, Hong, McWhirter, Robbins, & Pace, 2015; Todoran, 2018; J. Zhou, 2015). The reporting on xenophobic behaviors of faculty, institutions of research, and the Trump administration exemplify the need for further research on cultural

dissonance, intercultural relevancy, and the social relationships of international graduate students at American universities. These examples of attacks on cultural integrity are fodder for national news media outlets (Bhattacharyya, 2017; Dennis, 2017; Dunlap, 2017; Mervosh, 2019; Quilantan, 2018). The lack of empirical research concerning international graduate students' intercultural relevancy in the U.S. is important to understand given the current climate.

Some research studies related to the socialization experiences and intercultural aspects of international graduate students have focused on the psychosocial adjustments, acculturation, and cultural integrity (Andrade, 2006a; Phelps, 2016; Rice et al., 2009; Rose, 2005; Tran & Gomes, 2017; Linlin Xu & Grant, 2017; Zhang & Goodson, 2011b, 2011a). Six of these studies discussed the advisor relationship, peer groups, and social support as influential factors for international graduate students' persistence and success (Cotterall, 2015; Fotovatian, 2012; Gomes & Tran, 2017; Phelps, 2016; Rice et al., 2009; Zhang & Goodson, 2011b). Additional studies addressed the learning and academic experiences of international graduate students (Franken, 2012; Lichan Xu, 2015). These studies tended to examine psychological well-being and educational engagement (Curtin, Stewart, & Ostrove, 2013; Le & Gardner, 2010; Mallinckrodt & Leong, 1992; Szelényi & Rhoads, 2007).

Another group of quantitative studies concerned with international graduate student experiences focused on academic and social interaction (Curtin et al., 2013; Mallinckrodt & Leong, 1992; Trice, 2004; Trice & Yoo, 2007). Social supports, such as psychological counseling, and professional supports, like career readiness for a job in

their home country, were also positively associated with strong academic and social interaction. Overall, all these studies found that relationships, especially a strong advising relationship, positively influenced international graduate students' academic and social interaction.

The qualitative studies related to socialization, identity, and acculturation come from universities in Canada and Australia outside the U.S. context and had smaller sample sizes, under 20 participants (Cotterall, 2015; Fotovatian, 2012; Gomes & Tran, 2017; Manathunga, 2011; Phelps, 2016). In sum, these studies found international graduate students do indeed negotiate their identities in order to navigate their complex academic and social networks in graduate school. Connectedness with their advisor, as well as off-campus social networks contribute to their sense of social and cultural well-being and belonging. General recommendations of these studies centered around issues such as culturally responsive practices, the value of social relationships developed in graduate school, and the flexibility and open-mindedness towards communication differences. Fewer studies, however, investigate intercultural aspects during socialization at the graduate level for international graduate students in the STEM context in the U.S. (Crede & Borrego, 2014; Floresh-Scott & Nerad, 2012; Trice & Yoo, 2007).

Socialization

Socialization theory receives frequent criticism as an analytic lens for the study of graduate students in STEM education because the theory is too general and albeit neglectful of nondominant groups' experiences at American universities. The theory emphasizes assimilation and adoption of the dominant (in)group's knowledge, behaviors,

attitudes, and values (Antony, 2002; Felder, Stevenson, & Gasman, 2014; Manathunga, 2011; Twale, Weidman, & Bethea, 2016). Additionally, socialization theory in higher education research still needs to account for racial differences and varied cultural backgrounds, such as international graduate students (Gopaul, 2011). International students' individual variation is neglected (Johnson, Ward, & Gardner, 2017).

This investigation responds to some of those critiques of higher education scholars by focusing on an understudied population, STEM international graduate students in American higher education. One motivation to study international graduate students' socialization experiences empirically is to find out if there are shared experiences across such a diversified group of international graduate students. Another reason to investigate intercultural aspects of international graduate students is to learn more about the role that culture plays in the socialization process.

Socialization is the broader hypothetical home to the constructs under study. Socialization theory is used as an umbrella term to characterize experiences of social interaction, cultural congruity, identity prominence, and intercultural relevancy. These social and cultural aspects of graduate study are considered critical to successful socialization and well-being for students (Curtin, Stewart, & Ostrove, 2013; Myles & Cheng, 2003; Spaulding & Rockinson-Szapkiw, 2012). This study holds cultural perspectives as integral to the study of STEM international graduate students' experiences of American public research universities and graduate degree programs. To this end, the main outcome variable of this study is the international graduate students' perception of intercultural relevancy as part of the socialization process. Intercultural

relevancy assumes that one's culture of origin plays a significant role in their experiences within STEM research and the connections made with individuals on campus with shared cultural understandings.

Three concepts that are associated with the socialization process and may contribute to international graduate students' perception of intercultural relevancy are the social interactions students have with their mentor and peers, the extent to which culture is valued within the university and discipline, and international graduate students' identity prominence. First, the international graduate students' relationship with their faculty mentor and peers are the primary mode in which students learn the formal and informal expectations of being a graduate student. International graduate students who come from other cultures may bring with them diverse identities that frame the nature of the interaction between their advisors and peers. For example, a faculty mentor establishes the expectations for mentee by modeling behaviors of a research scientist within a research university environment. Then as part of the socialization process, students negotiate salient identities drawn out by their social interaction with advisor and peers (Holley, 2009, 2013; Twale et al., 2016; Weidman, DeAngelo, & Bethea, 2014). Communication patterns and linguistic differences between international graduate students and faculty and peers may lead to misinterpretations and miscommunications that can contribute to students' feelings of social isolation and otherness (Holmes, 2005).

A second concept important to the socialization process of international graduate students is cultural congruity. Cultural congruity measures the level of cultural fit within a university setting. Cultural congruity is understood in this study as international

graduate students' perceptions of how valued their culture is within a research university environment. Gloria and Robinson Kurpius (1996) refer to this cultural fit of an individual's internal value with those values of the university as cultural congruity.

The third concept important to the socialization process is identity prominence. Identity prominence reflects the perceived level of importance individuals place on their identities at any given time. Identity is defined as the most public self, encompassing professional and social self-concepts (Hogg, Terry, & White, 1995). Identities are both established and in flux. Identity is a critical aspect of the multi-faceted acculturation and socialization process (Tian & Lowe, 2013).

Statement of the Problem

The intercultural analysis bridges the relationship between socialization theory, culture, and identity for at the heart of each construct is the notion of negotiating the self and the ways we make meaning with others and ourselves through our social connections. Although international graduate students make up a large proportion of the next generation of students admitted to STEM programs in the U.S. and eventually entering careers in a complex globalizing world (Gargano, 2009; Phelps, 2016), socialization of international graduate students is an understudied area of the literature (Contreras-Aguirre & Gonzalez Y Gonzalez, 2017; Gopal, 2016; Posselt, 2016).

The high proportion of international graduate students that consistently invest and enter American Higher Education warrant us to conduct further investigation into their perceptions of the socialization process and identify factors that contribute to

international graduate student involvement, integration, and success in STEM (Marginson, Tytler, Freeman, & Roberts, 2013). International graduate students from different countries may have different socialization experiences. According to Gardner (2010), graduate student socialization is important to investigate for two central reasons: the first reason relates to the costs incurred by institutions and departments, and secondly, the impact on individuals' lives, career aspirations and identity when departure from an institution without a graduate degree occurs. Collectively students are considered crucial to supporting the research enterprise at research universities and after completion enter the workforce as vital sources of talent and innovation (Choudaha, 2017; Gopal, 2016; Gumport, 2016). If international graduate students are more likely to enter the American workforce, then there may need to be a developmental process that supports them throughout their education and professionalization for career readiness.

International graduate students who may have greater cultural distance between their culture of origin and the disciplinary culture may not have the same experiences and opportunities to integrate and socialize as domestic students or other international graduate students who may have less cultural distance. Cultural conflict is a term used to describe the conflict that occurs because of differences in cultural beliefs and values.

The internationalization of higher education in the United States and increased global competitiveness with other countries such as the UK, Canada, China, and Australia are beginning to jeopardize the U.S. advantage in attracting the most international graduate students (Taylor & Cantwell, 2015; Wendler et al., 2010). One impending threat to this symbiotic relationship is the rise of nationalistic federal policies

that impact American universities' global relations and international admissions practices. The Trump administration's unfortunate approach to immigration policies and visa requirements for entry into the U.S. have disrupted projections on international graduate student applications and enrollment patterns (Dennis, 2017; Mervis, 2017). According to data from the Student & Exchange Visitor Information System (SEVIS) international graduate student population declined by 6% between fall 2016 -fall 2017 (National Science Board, 2016). These quick changes to immigration policies and visa procedures threaten this lead in research innovation (Gumport, 2016). The most recent mar of immigration and visa regulations by the Trump administration is yet to be determined but is predicted to impede America's global competitiveness. Deans of U.S. graduate schools across the U.S. reported sharp declines in the number of applications from international graduate students in engineering and computer science programs. Similarly, a decline of international student enrollment occurred just after 9/11. Societal needs and events drive research innovation which in turn drives the growth of graduate education (Gumport, 2016, 2017). It is yet to be determined if international applications to graduate schools in the U.S. will begin to rise despite the isolationist political climate of the moment. However, more importantly, these new sentiments and policy acts pose a threat to the safety and security of international graduate students who are currently studying in the U.S. (National Foundation for American Policy, 2017).

Economically, we have yet to comprehend the broader financial implications of another sharp decline in international graduate students' enrollment at the graduate level and the impact of decreased enrollment at colleges and universities in the U.S.

(Choudaha, 2018; WES, 2018). The U.S. can expect a continued decline in international graduate student graduate applications and matriculation in areas like engineering and computer science, STEM areas where American workers are underrepresented. Further, American citizens make up less than half of graduate students in these areas.

Importantly, according to Han and Appelbaum (2016), 48% of international students would like to remain in the United States after degree completion. Job opportunities in the U.S. are a central factor in wanting to settle in the U.S. About 40%, a large pool of international students is undecided, and only 12% wish to leave upon completion. This undecided group is a potential talent pool who could become part of the skilled U.S. workforce particularly in high need areas of STEM fields, such as computer science and engineering. The U.S. has a shortage of domestic graduate students who can fulfill the needs of the burgeoning STEM workforce (Maltese, Potvin, Lung, & Hochbein, 2015). In the meantime, international graduate students have helped to alleviate the workforce gap in STEM. The United States benefits greatly from this innovative and diverse talent pool. A loss of such talent, also known as “brain drain” is predicted due to increased globalization and job market competition abroad. Therefore, it is crucial to understand more about the factors that influence international graduate students’ intercultural adaptation to U.S. education and to STEM specifically.

Purpose of the Study

The purpose of this multiple regression study was to determine the extent international graduate students’ mentor and peer relationships, cultural fit, and identity

formation influence intercultural relevancy as parts of the socialization process at American public research universities. The data originates from the Pacific Northwest Circle of Success: Mentoring Opportunities in STEM (PNW-COSMOS). PNW-COSMOS is an eight institutional alliance funded in 2014 by the National Science Foundation's Alliance for Graduate Education and the Professoriate – Transformation (AGEP-T) program, see Appendix B. As part for this grant, the Social Science Research Project (SSRP) Graduate Student Experiences (GSE) survey was administered to all graduate students in STEM at 12 research institutions from 2015-2017. This unique survey covered a range of topics associated with graduate students' socialization experiences in STEM including topics such as cultural congruity, environmental fit, and peer and mentoring relationships.

Research Questions

1. To what extent do international graduate students' social interactions with their faculty mentors and peers influence their intercultural relevancy in STEM?
2. To what extent do international graduate students' levels of cultural congruity influence their intercultural relevancy in STEM?
3. To what extent do international graduate students' professional and social identity influence their intercultural relevancy in STEM?

The relationships among the various constructs were analyzed using ordinary least squares regression (OLS) modeling approach, blocks of variables are sequentially added to the regression model. Given the different context of STEM disciplines and the

individuals' background characteristics, gender, race/ethnicity, year in program, degree type, discipline, and institutional type were used as statistical controls

The diagram in Figure 1.1 shows the proposed relationships among the variables in the research questions. These relationships will be tested using a series of OLS regression models to test the strength and direction of each association.

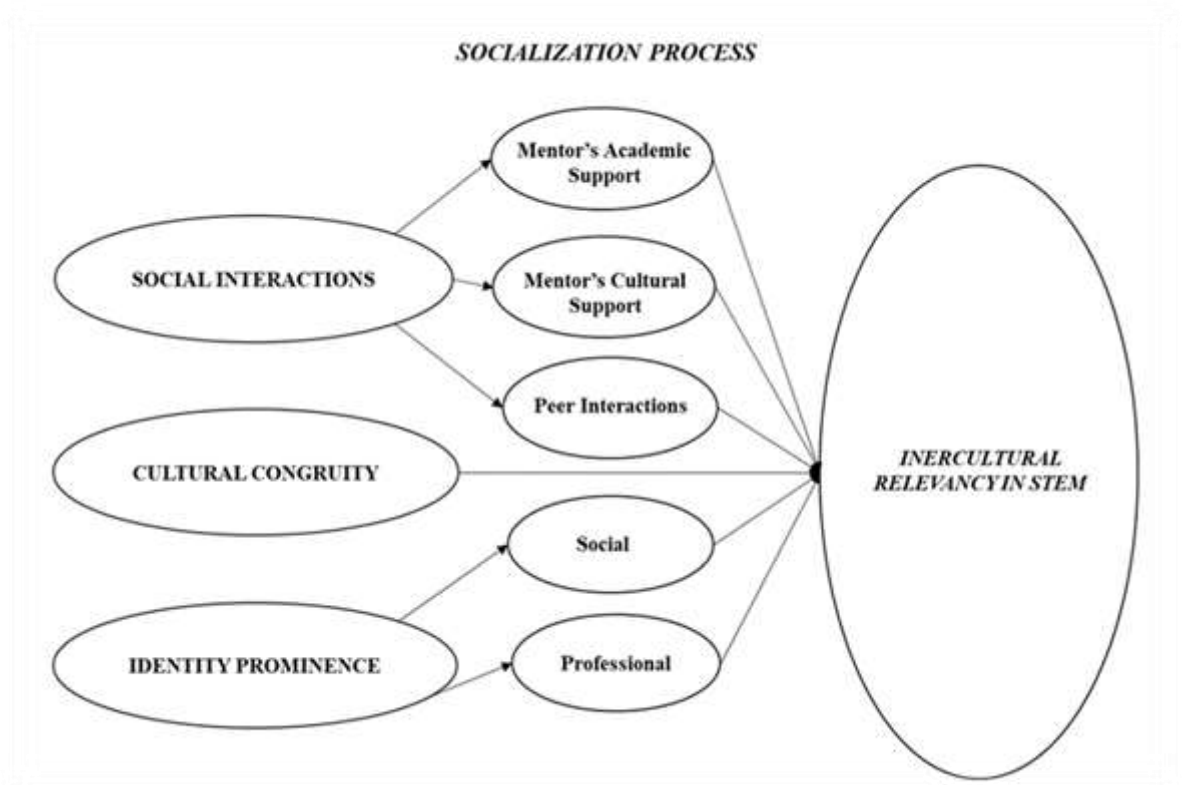


Figure 1.1. Relationships among the study variables: Social interactions, cultural congruity, identity prominence, and intercultural relevancy of STEM.

Theoretical Framework

The intent of this quantitative study was to investigate possible associations between faculty and peer relationships, cultural fit, identity and intercultural relevancy as parts of the socialization process of STEM international graduate students at American

public research universities. This study examined the extent that individuals' characteristics, and the institutional context contributed to other explanatory insights on the possible associations between socialization factors. The theoretical framework is described in more detail in Figure 2.1 in Chapter Two. The figure outlines the distal and proximal contextual factors that frame from my investigation on the possible associations among socialization experiences of STEM international graduate students at American public research universities.

Socialization is a process where one seeks membership into a group or social structure through interaction with that group or social structure(s). The assimilative process frequently involves the adoption, and subsequent internalization of knowledge, attitudes, behaviors, and values of the in-group (i.e., academic discipline). Socialization is applied as an umbrella term for the constructs under study. The main outcome construct is intercultural relevancy that is operationalized by two dependent variables including cultural integrity in STEM and connections with cultural representatives. Further, the explanatory constructs that operationalize socialization are mentor's cultural and academic support, peer interactions, cultural congruity, and identity prominence. Social interactions, a somewhat abstract notion, is defined in this study as the day to day communications, verbal and non-verbal, with other people from our immediate research sphere of influence. Additionally, cultural congruity represents students' perceived value of their culture in the new environment, the alignment between the new culture and their culture of origin, and the degree to which a university supports the unique needs of

students. Lastly, identity prominence characterizes the extent that students perceive their professional and social identities as important in that moment.

The Significance of the Study

This study aims to uncover the extent to which intercultural aspects are relevant to STEM international graduate students' socialization. Learning more about international graduate students' characteristics and experiences in the U.S. is critical for two reasons. First, rapidly changing mobility patterns and access to higher education have increased competitiveness in the recruitment and retention of international STEM talent. With the internationalization of higher education opportunities have expanded worldwide (Bodycott, 2012; Knight, 2004). Consequently, if international graduate students do have negative experiences while in the U.S., they may be less likely to remain here. Additionally, if they do return to their home country or settle elsewhere their negative experiences reflect poorly on the U.S. and diminishes our ability to recruit and retain international talent. Another reason is the diversity international graduate students bring with them when they choose to come to the U.S. for graduate studies in STEM. Their participation gives disciplinary cultures more opportunities to interact and engage in international scholarship.

We know American research universities and disciplinary cultural norms shape day to day interaction that then shape individual meaning making and self-concept (E. Zhou & Okahana, 2016). Investigating the strength of association among central aspects of the socialization process (including intercultural relevancy in STEM, social interactions, cultural congruity, and identity prominence) can add much to the

conversation about graduate education reforms (Choudaha, 2017; Todoran, 2018). This work intends to understand the current state of international graduate students' perceptions of their experience in the U.S. from an empirical standpoint. The findings, results and recommendations can inform many stakeholders of graduate education, especially those people who are responsible for implementing innovative program supports on campuses.

A significant contribution in this study is the use of a National Science Foundation survey and data set from 12 participating public research universities from across the United States. It is one of a few quantitative investigations that focuses on the role of culture in the socialization process (as measured by cultural congruity, social interaction, identity, and intercultural relevancy in STEM) of international graduate students in the United States. Analyzing understudied aspects of the socialization process in relation to culture and identity can help institutions in enrollment management, admissions practices, and healthy retention and completion of all students. It is critical now to better understand current attitudes and perceptions towards the quality of interactions international graduate students experience at American universities experience, and the degree to which intercultural relevancy in STEM are associated.

Definition of Terms

The variables, key concepts, and theoretical constructs that frame the study and research questions are described in this next section.

International Graduate Student

Any graduate student who is not a U.S. citizens or permanent resident of the United States and who is pursuing a graduate degree at an educational institution approved by the U.S. Citizenship and Immigration Services (USCIS) is considered an international student. The National Foundation (NSF) also refers to international students as temporary visa holders. Temporary visa holders need to apply for an F-1 or J-1 visa to study in the United States. This visa must be approved prior to enrollment for graduate courses at American colleges or universities, and admission. International graduate students are sometimes referred to as foreign students. International students' must also certify that their primary intent is to obtain an American a graduate degree and return to their home countries, also known as providing “non-immigrant intent”.

Socialization

The term socialization is defined as “the passage through which an individual learns to adopt the values, skills, attitudes, norms, knowledge needed for membership in each society, group or organization” (Johnson, Ward, & Gardner, 2017).

Intercultural Relevancy in STEM

Intercultural relevancy in STEM can be described as a nonlinear, dynamic, and interactive process in which a person makes meaning, interacts, integrates, and learns the values, skills, attitudes, norms, and knowledge to effectively participate in graduate school. It is through the shared meaning within multiple cultures that help to form an interculturally, committed professional, and transnational identity (Museus & Quayle,

2009). For this study, intercultural is a term that refers to the interaction among multiple cultures or taking place between cultures such as, an individuals' nation of origin, ethnicity, or racial group. The intercultural framework of Museus and Quaye (2009) focuses on the interactions between students' cultures of origin and the cultures of immersion. As a latent construct of the study, intercultural relevancy in STEM is operationalized by two dependent variables, scales that measure the perceived value of cultural integrity in STEM and connections with cultural representatives.

Social Interactions

Socialization is operationalized in this study as social interaction and is measured through the following explanatory variables: students' reports on advising behaviors such as, mentor's cultural support, mentor's academic support, and students' perceptions of their peer interactions. "Most social interaction is between persons who occupy positions (statuses) in groups or organizations in society. Interaction is thus not between whole persons, but between aspects of persons having to do with their roles and memberships in particular groups or organizations: their identities." (Stets & Burke, 2014).

Cultural Congruity

Cultural congruity "a match of one's cultural or personal values with those of the university" (Gloria & Robinson Kurpius, 1996). Further, it reflects international graduate students' perceived value of their culture in the new environment, alignment between new culture and their culture of origin, and how well the university supports the unique needs of international graduate students.

Identity Prominence

Identity is defined as the most public or socially constructed aspect of self.

Hierarchical identity salience places importance on one identity over another in different social situations. Identity prominence can also be labeled by the more commonsense term “importance,” it can be defined as the individual’s subjective sense of the worth or value of an identity to himself or herself (Brenner, Serpe & Stryker, 2014; Ervin and Stryker 2001).

The Carnegie Classification of Institutions®

Beginning in 1970, the Carnegie Commission on Higher Education created a classification system of U.S. postsecondary institutions in order to assist its programs of higher education research and policy studies. The Carnegie Classification of Institutions® has been the most commonly used system for categorizing and describing existing differences and commonalities of American colleges and universities. The classification assigned to an institution is based on the level of degree awarded and the disciplinary area in which the degree is earned. Further, student enrollment numbers, admissions selectivity, and the amount of federal research monies awarded also contribute to the basic classification of an institution. This study assumes the 2015 definition and classification of doctoral universities. According to the 2015 Carnegie Classification of Institutions® doctoral universities are categorized as highest research universities, higher research universities, and moderate research universities (The Carnegie Classification of Institutions of Higher Education, n.d.).

Assumptions

Fundamental to graduate student socialization theory are several assumptions. The first assumption is that identity is integral to the process of becoming (i.e., a scientist, researcher). Identity includes professional and social. These two dimensions of identity play an important socializing component for the way international graduate students interact with their advisor, peer, and environment. The next assumption is that the interaction with others is also part of the socialization process and is dialectical and ongoing. A third assumption is that the study assumes that international graduate students' culture of origin plays a role in the socialization to American University.

Limitations

There are several limitations related to the research design and data collected. First, as a cross-sectional survey design, I cannot draw any conclusions around the growth and development of international graduate students or their travel experiences before coming to the U.S. The length of time they have lived in the U.S. and the number of times they have traveled abroad is unknown. This omission of data may limit the analysis because time influences acculturation and the more time or travel experience the less likely students will experience culture shock. Time spent in the U.S. provides students with previous understanding of American norms, expectations, and attitudes, especially if they have travelled to the U.S. or other nations before attending graduate school. Those students who are new to the U. S. may experience culture shock and acculturative stress due to lack of exposure (Boafo-Arthur, 2014; Mena, Padilla, &

Maldonado, 1987; Smith & Khawaja, 2011) may place greater value on notions of intercultural relevancy. Unfortunately, with self-reported data those who responded to the survey may tend to be more engaged than those who declined the survey invitation. Another limitation is that the three scales included in the survey cultural congruity scale, mentor's cultural support, and peer interactions scales were originally intended for undergraduate student populations and in some cases for students of color. Additionally, the measure of race/ethnicity is self-reported, and uses American conceptions of race/ethnicity applied in sociology (Phinney, 1992). The race/ethnicity items differ from the National Science Foundation's definitions of race/ethnicity (National Science Foundation National Center for Science and Engineering Statistics, 2013; Teranishi, 2007). It differs from standardized NSF ethnic and racial measure in that Arab/Middle Eastern is included as a stand-alone category. Another example of race/ethnicity limitation is how Asian/Pacific Islanders are classified in one category instead of two distinctive racial categories, Native Hawaiian or Other Pacific Islander (Hawaiian, Guamanian, Chamorro, Samoan, or other Pacific Islander) and Asian (Asian Indian, Cambodian, Chinese, Japanese, Korean, Malaysian, Pakistani, Filipino, Thai, or Vietnamese). A larger caveat is that the specific nation of origin was excluded as an item on the survey. In the original survey global region demographics were not included as items on the survey. This aspect is the most problematic as it limits interpretations I can draw about differences between ethnic and racial groups by nation of origin.

To conclude, the study's focus on STEM, resulted in the collection of student data from 12 research universities. The original sampling plan approach focused on STEM

programs recognized by the National Science Foundation and excluded the social and behavioral science programs, see Appendix D. Further, humanities, biomedical sciences, education, nursing and professional graduate programs were omitted from the original data collection.

Delimitations

I delimited the study sample to STEM international graduate students at 12 American public research universities. The 12 universities of the 13 institutions surveyed met the Carnegie classification criteria of higher and highest doctoral research institutions.

Chapter One Summary

This survey research examines the relationships between intercultural aspects of socialization among international graduate students in STEM. Specifically, I explore the association between international graduate students' intercultural relevancy in STEM and social interactions with mentor and peers, levels of cultural congruity, and identity prominence. If American institutions, faculty and administrators want to foster healthy and mutually beneficial relationship between them and international graduate students, then they need to know more about the particulars of their socialization experiences. Socialization theory is the broader theoretical home of the constructs under study. For this study, socialization is characterized as social interactions, cultural congruity, identity prominence, and intercultural relevancy in STEM. Cultural integrity in STEM and

connections with cultural representatives represent the two observed variables of the latent construct intercultural relevancy in STEM. The latent construct of social interactions is characterized by three observed variables, which include mentor's cultural support, mentor's academic support, and peer interactions. Last, identity prominence is operationalized by two observed variables that measure professional identity and social identity.

CHAPTER TWO

LITERATURE REVIEW

Introduction

In Chapter Two, the issues and trends, social theories, and literatures germane to this investigation into the influence of socialization experiences of international graduate students and intercultural relevancy in STEM. This chapter is organized in two sections. The first section is an overview of several historical events related to international graduate student participation in American graduate education. Followed by the current state of understanding concerning more recent trends about the enrollment of international graduate students. The economic implications of international participation in American graduate education are discussed. In the second section, I synthesize the main theoretical areas that shape the study — graduate student socialization, intercultural studies, and social psychological theory. In this study socialization is an umbrella term characterized by intercultural relevancy, social interaction, cultural congruity, and identity prominence. I explain how these social theories relate to the larger themes from the literature related to graduate student socialization. In the last section I review the various definitions and meanings of the study variables. Intercultural relevancy in STEM is comprised of two dependent variables measuring cultural integrity in STEM and connections with cultural representatives. Socialization experiences of international graduate students were represented by three constructs that comprise five independent variables — social interaction (mentor's cultural support, mentor's academic support, and

peer interaction), cultural congruity, and identity prominence (social and professional identity). International graduate students' experiences and empirical studies related to culture and identity and their roles in shaping cultural meaning-making systems for international graduate students in STEM are synthesized and gaps in the literature concerning intercultural relevancy and cultural congruity of international graduate students in STEM are identified.

The literatures of higher education, sociology, communications, intercultural studies, and STEM disciplines were examined. The strategies used to identify appropriate literature included the performance of multiple searches using EBSCO, Psych Info, and Academic Search Complete databases. The terms I included in my searches were a combination of key terms such as, international, foreign, graduate student, doctoral, STEM discipline (science, math, engineering and technology). After culling and finding relevant literature some initial categories began to emerge. Key journals from diverse subject areas were also identified. After each review, I organized relevant literature around several broad themes. Manuscripts were categorized as theoretical, empirical, or as news and special reports. These themes include graduate student socialization (doctoral/graduate studies), with specific focus on STEM fields broadly, discipline, identity (social and role), culture (intercultural and acculturation), and international/foreign graduate students. To confirm the relevancy of studies and discover concept overlap I also examined literature reviews on the topic (Zhang & Goodson, 2011b). These keyword terms helped to complete a final systematic review until saturation was reached.

This chapter provides understandings into both the specific historical juncture into which today's international graduate students find themselves and the current state of understanding around the socialization of international graduate students in STEM graduate programs in the United States. I seek to understand the degree to which integral aspects of socialization, which in this study are characterized as cultural congruity, social interaction, identity prominence, and intercultural relevancy are related. These complex processes of socialization are analyzed in the context of American graduate education and do consider graduate education's place among the dynamic economic, social, and political forces of our time.

Historical Overview

Since its inception, the relationship between industry and graduate education in the United States and abroad has been reactive to the needs of the populace and nationalistic ideals. We can trace the roots of internationalization of higher education in the United States to the late nineteenth century, where upon American scholars, students, and professors who sought in-depth educational programs spent significant lengths of time as international students at German universities before coming back to the U.S. to begin their careers (Wolken, 2018; Bonner, 1963; Diehl, 1978). Higher education historians have attributed the development of the American university to the influence of the "German model" of higher education, which came into being based on American interpretations and the reconfiguration of the German university system. The Germans may have invented the research ideal, but the Americans invented an institution to house

and perpetuate it (Wolken, 2018). Specialized research training did not fit into the general college curriculum in America and so an advanced course of specialized training that came to be known as graduate education or a graduate school had to be segmented from the general university course. The German practice was transformed in this way into America's most substantial contribution to the development of the research university. In a recent article about "internationalizing" the American university, Adam Nelson (2005) argues that an interesting outcome of Americans as international students in Europe led to a movement that moved them towards 'more nationalistic sentiments (p. 433). As he explains,

Indeed, it may be the case that, in a context of increasingly nationalistic ideologies circulating in the United States and Europe at the time, Americans who studied overseas may have 'learned nationalism abroad,' first working under foreign mentors directing their own research toward national service and then reproducing their mentors' methods and motives upon their return to the United States. (pp. 433-434)

In 1861, the first doctoral degree was awarded in the United States, since that time graduate education has evolved to become a global enterprise the advanced degree model adopted around the world (Gumport, 2016; LaPidus, 2001). Currently, more than 400 universities award doctoral degrees, a dramatic increase since 1920, when only 14 doctoral degree-granting institutions existed in the United States (Walker, Golde, Jones, Bueschel, & Hutchings, 2012). Master's degree programs and professional certificate programs have seen dramatic increases and continued to rise (Allum, 2014). The rise in the number of people earning master's and doctoral degrees can be attributed to increased changes in attitudes towards the investment in human capital globally. Additionally, the introduction of new fields and faster time to degree in STEM has also led to the increase

of doctorates awarded (SED, 2017). In 2015, the number of STEM doctoral degrees earned by international graduate students grew to reach 14,037, an increase by 30% between the years 2005 and 2015, though only 2% since 2014 (SED, 2017). Between 2011 and 2015, 86% of the doctoral degrees awarded to international graduate students were in STEM, in comparison 70% of the doctorates earned by U.S. citizens and permanent residents reached 70% (SED, 2017). In this next section a more detailed look at recent trends may help to explain international graduate success in the United States and some of the challenges. Further, international graduate students also benefit from their participation in the internationalization of U.S. graduate education. Since its inception, graduate education in the U.S. has been considered a global enterprise. Graduate education is a mechanism for personal development, career advancement, and global mobility for international graduate students. International graduate student participation also promotes a diplomatic social good that is intertwined with research innovation.

STEM International Graduate Students: Trends in the U.S. Context

In looking at the scholarship on graduate education, several social, political, and economic forces influence the role of internationalization of graduate education and international graduate student experience: competing global markets, international graduate student growth, and shifting national policies. The research on the internationalization of STEM to meet growing societal needs has increased in the last fifteen years (SED, 2017). Marginson (2013) refers to international students as self-

determining agents and a distinct population within graduate education who have specialized needs because of their transient stays in other countries and their movement between nation-states. For example, when migrating between nation-states safety and security is not necessarily guaranteed when going through U.S. Customs and Border Protections (Anderson, 2017; Banjong & Olson, 2016; National Research Council, 2005; Todoran, 2018). Navigating health system differentials can also be a detriment to being safe and secure. The United States has long been a leading destination of learning for international graduate students, mostly in the more globally competitive disciplinary areas of STEM. Choudaha (2017) identifies key events and trends impacting international student mobility within temporal periods as waves, each one spans seven years between 1999 and 2020. The first two waves coincided with 9/11 and the global financial recession. The third wave is being shaped by a combination of three events – the slowdown of the Chinese economy, the 2016 UK referendum to leave the European Union (EU), and the 2016 American presidential election.” (p. 826). He further asserts universities face financial and competitive pressure to attract and retain international students. Higher education institutions need to innovate to increase international student enrollment and build in corresponding support services “that advance student success including expectations of career and employability outcomes.” (p. 825).

Enrollment in the United States

The low enrollment of Americans in STEM is well documented, less than “40% of students who enter college intending to major in a STEM field complete a STEM degree” (Eubanks-Turner, Beaulieu, & Pal, 2018). Alternately, the number of

international graduate students in STEM doctoral programs has doubled over the past thirty years. Should this trend continue by 2020 almost half of the STEM doctoral degrees will be earned by international graduate students (Han & Appelbaum, 2016). These pressures to advance in STEM innovation within the United States implicate a pronounced demand to prioritize global recruitment in order to meet critical labor shortages in STEM (Institute of International Education, 2017; Mendoza, 2007; NAFSA: Association of International Educators, 2006). This trend in urgency raises even more concerns in that the United States’ “ability to produce a workforce capable of leading a global economy is compromised by the gap between the projected need for more scientists, engineers, and technically proficient workers ...” and the country’s ability to train a diverse workforce with the necessary talents in STEM (Goldstein, 2012). In 2011, the United States was ranked 48th in quality of K12 math and science education by the World Economic Forum (Vest, 2011). Additionally, results from the biggest cross-national tests, Programme for International Student Assessment (PISA) in 2015 place the U.S. 38th out of 71 countries in math and 24th in science (Desilver, 2017). These statistics show why the United States’ global ranking in graduate degree attainment in STEM fields lags behind other countries. It is also the U.S. that benefits from international graduate students who have filled the employment gaps in fields of study such as, engineering and computer science (Anderson, 2017).

Currently, the U.S. market leads in enrolling and matriculating the most international students. The 2015 CGS International Graduate Admissions Survey shows participating U.S. research universities “received over 1.6 million applications for

admission to graduate programs for studies beginning in Fall 2015.” Internationals made up 47% or 786,363 of those applications and of those international graduate students who applied only 35% or around 215,156 of the 600,000 who were offered admission enrolled (Okahana, 2017). However, this lead is projected to decline in the next decade as other nations increase in their ability to attract and recruit stellar students from around the globe (SED, 2017).

Competing Global Markets and Revenue Decline

Nation-state mandates that conflict with institutional goals for internationalization are pertinent to university and STEM leaders as a large percentage of Ph.D. students are international. Increasingly state budget cuts have led to the development of diversification of funding streams. More and more universities have come to rely on international student tuition dollars to subsidize domestic students. International graduate students also contribute intellectual and social diversity and help research universities to internationalize and compete in global markets (Cantwell & Maldonado-Maldonado, 2009).

Recent events at the federal level have disrupted U.S. Citizenship and Immigration Services (USCIS). Shortsighted policies further harm research enterprises, and the harm done to the research enterprise stalls innovation. Topical reports on enrollment show a 3% decrease in the number of applications from international students in engineering and computer science programs (Mervis, 2017; Okahana, 2017). This recent 3% decline in international graduate student applications to U.S. graduate programs in STEM have raised concerns (AACRAO, 2017; Okahana, 2017). Ultimately,

should this trend continue research and society will suffer considerable losses in human capital due to decreased access to education, loss of knowledge and diverse thinkers who can move society forward and add incrementally to the knowledge economy (Freeman, Marginson, & Tytler, 2015).

Pivotal Events and Policies

After the terror attacks of September 11, 2001, a sharp decline of international graduate student enrollment occurred when Congress made substantial changes to student visa policy. These significant changes altered the procedures international people follow to obtain visas for study in the U.S. for the worse (CGS, 2007; Business Week, 2006). The number of applications from potential international graduate students decreased from 264,749 to 259,717 between 2001 and 2006 (Open Doors, 2007).

Following the 2016 presidential election, federal immigration policies in the U.S. appear to be in flux, contradicting goals to internationalize at most U.S. universities, which aim to attract, enroll, and retain international graduate students. Nationalistic rhetoric appears to be on the rise, and fringe political movements are now more viable in the United States (U.S.) and the United Kingdom (UK). Pressures to internationalize higher education run counter to the series of Executive Orders – 13789, 13780 and 9645 – signed by President Trump.

The first policy is known as the *Protecting the Nation from Foreign Terrorist Entry into the United States*, also came to be known as the “Muslim ban” blocked citizens from seven majority-Muslim countries — Iraq, Iran, Sudan, Somalia, Libya, Yemen and

Syria — including all refugees from entering the U.S. and came into effect between January 27, 2017 to March 16, 2017. After protests and significant controversy, 13789 was revoked and replaced by Executive Order 13780, a more palatable decree. Followed by additional changes on September 24, 2017, for three more countries — Chad, North Korea, and Venezuela — were added and Sudan removed from the list of banned countries. The Trump initiative drew harsh criticism that resulted in months of deliberation and litigious activity. The Supreme Court will allow the third version of the Executive Order 9645 travel ban to operate even though legal challenges against it are ongoing (New York Times, 2017). The political and legal uncertainty is particularly relevant for international students who traverse multiple global fields (Phelps, 2016; Szelényi & Rhoads, 2007). Given the complex nature of scholarly pathways, international graduate students perceived attitudes might provide us with insight into the power and knowledge structures embedded in academic culture (Gopaul, 2011). One important line of inquiry that international graduate students may provide insight into the academic culture is through their socialization experiences of American higher education.

Theoretical Foundations

Next, I describe the theoretical foundations for this study on the socialization of international graduate students in STEM. These include graduate student socialization theories, intercultural perspectives, and identity theory. Social, cultural and intercultural interaction, and identity are important constructs that undergird the socialization process. These core concepts of the study are operationalized as variables and include social

interaction (mentor's cultural support, mentor's academic support, and peer interaction), cultural congruity, identity prominence (professional and social) and intercultural relevancy in STEM. In the following section I clarify how these theories of socialization and culture support the study (Crede & Borrego, 2014; Zhang & Goodson, 2011b; Yuefang Zhou, Topping, Jindal-Snape, & Todman, 2008). Specifically, this is a study about the meaning and experience given to culture in graduate student socialization, focusing on STEM international graduate students at American public research universities.

Socialization Theory

In the last ten years, studies related to attrition and completion have increased the discussions on the socialization process and its association to student success. There is an increasing body of research on international graduate students in STEM, however, this research has neglected to understand the socialization of international graduate students to American Higher Education and specifically the role that culture may play in this process. The facets of socialization under consideration include — social interaction, culture, and identity. It is important to understand the international graduate students' experiences given the external pressures of an ambiguous political climate, changes in nation-states, and federal funding that continues to change.

Weidman, Twale, and Stein (2001) adopted the sociological theory of role acquisition theory to theorize on the graduate student experience. They adapted the four stages of passage of role acquisition initially described by Thornton and Nardi (1975).

The four stages are: anticipatory, formal, informal, and personal. In the frequently cited monograph on graduate student socialization Weidman, Twale and Stein (2001b) made recommendations to test the model empirically. Following up, empirical research conducted by Gardner (2009) identified three “phases of challenges and support” along the doctoral continuum and doctoral student development phases. In this study, I circle back to the earlier origins of role acquisition and identity theory and commitment (Hogg et al., 1995; Stets & Burke, 2000; Stryker, 1968) to understand better and draw explicit connections to the empirical research on doctoral development. Broadly, socialization theory is understood as “the process by which persons acquire the knowledge, skills, and dispositions that make them more or less effective members of their society” (Weidman et al., 2001). Coombs (1978) discusses the process as “transforming a human being into a self who possesses a sense of identity and is endowed with appropriate attitudes, values, and ways of thinking, and with other personal yet social attributes” (p. 14).

Unlike traditional development theory, doctoral student development and socialization are closely linked. However development domains include psychosocial development, cognitive-structural development, and social identity formation. Psychosocial development is the growth related to how students see themselves and their abilities, their relationship with others and their future lives (Chickering & Reisser, 1993). Social identity encompasses “how individuals construct their various social identities, namely, race/ethnicity, gender, and sexual orientation” (McEwen, 2005, p. 13). Identity formation can be considered a salient self-concept “Social identities if merely assigned by others, are not part of an individual’s core sense of self—only the social

identities that are salient are integrated into the core.” (Alvarado & Hurtado, 2012; Hughes & Hurtado, 2018). It is in this space of the socially constructed aspect of self where the socialization process is most ripe and the most vulnerable because of the anticipatory nature of the training, not yet a scientist but expected to be one. Anticipatory socialization can help to explain the difficulty graduate students encounter when expectations of the expected professional identity are unclear, yet one’s social identity serves as a source of strength as the professional identity is in flux during the graduate phases of development (Bess, 1978; Jung, Hecht, & Wadsworth, 2007; Thornton & Nardi, 1975). The importance that an individual’s culture plays in their identity formation and socialization process warrants greater exploration for how international graduate students perceive and navigate intercultural spaces found in graduate education.

Cultural Perspectives and Socialization

International graduate students come from wide-ranging social, cultural, and personal backgrounds. Several additional theories have been posed using a cultural approach to better explain the socialization process for ethnically diverse students (Kuh & Love, 2000; Museus & Quaye, 2009; Rendón, Jalomo, & Nora, 2000). Current socialization theories may rely on and expect students to compartmentalize or even detach from their culture of origin to successfully assimilate into the new academic culture (Twale et al., 2016). Tierney refers to this separation as cultural suicide (Tierney, 1999). Therefore, adoption of an intercultural perspective is assumed to be better for understanding students’ perceptions of their cross-cultural interaction both social and academic because from this understanding we can learn what contributes to positive

cross-cultural socialization and specifically, the value international graduate students place on intercultural relevancy in STEM.

A bicultural socialization model was first introduced by Kuh and Love (2000). This model aimed to account for and explain the substantive cultural differences that exist among undergraduate students as they navigate higher education. They advocated a type of interaction exchange model comprised of a series of propositions. The objective of these propositions is heuristic (Kuh & Love, 2000, p. 200). The cultural suggestions clarify aspects of congruency between a students' cultural heritage and their current institutional culture. The propositions promoted understandings about culture and the ways diverse students experience and navigate the institutional environment. The 8 statements encompass a cultural analytic lens to encourage future inquiries.

Museus and Quaye (2009) extend the work of Kuh and Love (2000). Their recommendations come from empirical research, which is then used to revise the eight propositions. They introduced the intercultural framework as a means for researchers to understand more fully the experiences of undergraduate minority students' socialization and persistence in college. It too is comprised of eight propositions, that offer both socio-psychological and structural influences to explain their socialization and how underrepresented students acclimate to the college environment (Johnson, Myers, Ward, Hollist, & Sanyal, 2017). These eight propositions are described as: (1) Minority students' college experiences are shaped by their cultural meaning-making systems; (2) Minority students' cultures of origin moderate the meanings that they attach to college attendance, engagement, and degree completion; (3) Knowledge of minority students'

culture of origin and immersion are required to understand those students' abilities to negotiate their respective campus cultural milieus; (4) Cultural dissonance is inversely related to minority students' persistence; (5) Minority students who experience a substantial amount of cultural dissonance must acclimate to the dominant campus culture or establish sufficient connections with cultural agents at their institution to persist; (6) The degree to which campus cultural agents validate minority students' cultures of origin is positively associated with reduced cultural dissonance and greater likelihood of persistence; (7) The quality and quantity of minority students' connections with various cultural agents on their respective campuses is positively associated with their likelihood of persistence; and (8) Minority students are more likely to persist if the cultural agents to whom they are connected emphasize educational achievement, value, educational attainment, and validate traditional cultural heritage. Propositions 1, 3, and 4 are like the bicultural socialization framework posed by Kuh and Love.

The impact of culture on international graduate students' experiences needs more exploration and explanation to better understand the unique challenges and characteristics of specific domains and the intersectionality of within-group diversity. International student includes individuals that represent a myriad of nation-state perspectives and cultural backgrounds. International graduate students are engaged with the relational nature of scholarly work, mentoring and scientific discovery within different disciplines. Research shows that positive socialization in STEM is critical to professional, personal and academic development of students (Gardner, 2008; Gopaul, 2011; Lott, Gardner, & Powers, 2009; Twale, Weidman, & Bethea, 2016). Research also shows that international

graduate students' experiences vary in degrees of integration and alternately alienation within American public research universities and abroad (Guo & Chase, 2011; Le & Gardner, 2010). Especially in cases where faculty ignore international graduate students' national, racial, and social backgrounds and place higher value on American cultural norms (Mervosh, 2019).

Dissimilar communication styles and linguistic differences that may arise between international graduate students and their faculty mentor and peers may lead to misinterpretations and miscommunications that can contribute to students' feelings of social isolation and otherness (Holmes, 2005). Whether it is between a faculty mentor or among peers these feelings of isolation can interfere with a healthy graduate school experience. In the next section I explain how the four theoretical constructs — intercultural relevancy, social interaction, cultural congruity, and identity — are central to this study on the socialization of STEM international graduate students.

Intercultural Relevancy

The main construct under investigation are international graduate students' perceptions of intercultural relevancy in STEM. Intercultural relevancy is a construct created from an intercultural framework of minority student persistence (Kuh & Love, 2000; Museus & Quaye, 2009). Intercultural relevancy in STEM assumes that one's culture of origin is significant in STEM research and the connections made with people from similar cultures or cultural representatives. Intercultural relevancy in STEM assumes that one's culture of origin is significant in STEM research and the connections made with people from similar cultures or cultural representatives. The intercultural

relevancy scale was designed to measure the importance and extent to which differences exist among racial groups and the association between one's culture, STEM research, and the STEM culture in graduate school (Hollist, Myers, Ward, Johnson, & Sanyal, 2017; Ward et al., 2017). Six of the intercultural framework's propositions were adopted and operationalized as cultural integrity in STEM and connections with cultural representatives to measure the latent construct of intercultural relevancy in STEM, which serves as the main construct of this study. Even though these measures were originally conceived for another population, when applied to other culturally diverse groups it may help us to understand more about the relationship between intercultural aspects of socialization students encounter at American public research universities.

The construct of intercultural relevancy in STEM was conceptualized from approaches and cultural perspectives found in the higher education literature (Dowd, Sawatzky, & Korn, 2011; Kuh & Love, 2000; Museus & Neville, 2012; Rendón et al., 2000; Tanaka, 2007; Tierney, 1999). Kuh and Love (2000) argue for the use of culture as an analytical lens in higher education research. At this point in time Durkheim's theory of suicide which came from sociology was frequently adopted by scholars to research student departure (Durkheim, 1951; Tinto, 1987, 1993). As an alternative approach Kuh and Love offered a set of eight propositions to encourage the use of cultural perspectives in higher education research on departure. The authors' intent of the propositions is heuristic (p. 200), a heuristic in that it provides a structure to embark on new learning and understanding by encouraging inquiry.

Further along, the eight propositions were empirically tested in a series of research studies looking at the persistence of racial and ethnic minority undergraduate students (Museus & Maramba, 2010; Museus & Neville, 2012; Museus, Palmer, Davis, & Maramba, 2011; Museus & Quaye, 2009). Museus and Quaye enhanced the preceding claims through empirical research that tested and validated Kuh and Love's eight propositions to better inform the future research on minority college student persistence and departures. The propositions were modified to include new-found cultural notions referred to as individual cultural agents and cultural integrity. Notions identified in the research findings which resulted in the development of the intercultural framework, a modified version of the culturally based statements Kuh and Love proposed.

These two related lines of inquiry and approaches inform the analytical lens and method of my study that examined the socialization experiences of international graduate students from a cultural perspective. Further, my theoretical lens was also informed by a large body of work by several sociologists who research intercultural relations and studies (Hammer, Bennett, & Wiseman, 2003; Y. Y. Kim, 2001, 2008). These three concepts shaped the development of my analytical lens and come varied scholars who expanded cultural perspectives for higher education research and intercultural studies.

The main outcome variable, intercultural relevancy, is represented as the meaning and value of culture for students in STEM and the socially supportive relationships they have with cultural representative(s) (Gomes & Tran, 2017; Museus & Quaye, 2009).

Figure 2.1 situates the study variables of interest for my research as intercultural socialization experiences. Intercultural relevancy in STEM is the cultural construct

delineated into cultural integrity and connections with cultural representatives, both which are found to be integral to understanding undergraduate students' experiences more holistically. Cultural integrity honors and promotes a person's cultural identity as they interact within and engage others in alien environments (Andrade, 2006a; Museus & Quaye, 2009; Tierney, 1999). In this study, cultural representatives are people who identify with the same culture and share the same beliefs and customs on the GSE survey. It measures students' perceptions about the value of cultural representatives in the graduate education milieu. Students were asked about the quality and quantity of a graduate student's connections with various cultural representatives on their own campuses is positively associated with the likelihood of persistence.

One common attribute of these propositions is the significant role that the students' cultural backgrounds play in their interactions and academic experiences (Johnson, Myers, Ward, Sanyal, & Hollist, 2017). In response to understanding the role that the perceived value of culture plays in students' academic experiences, Gloria and Rodriguez (2000) introduced the construct of "cultural congruity".

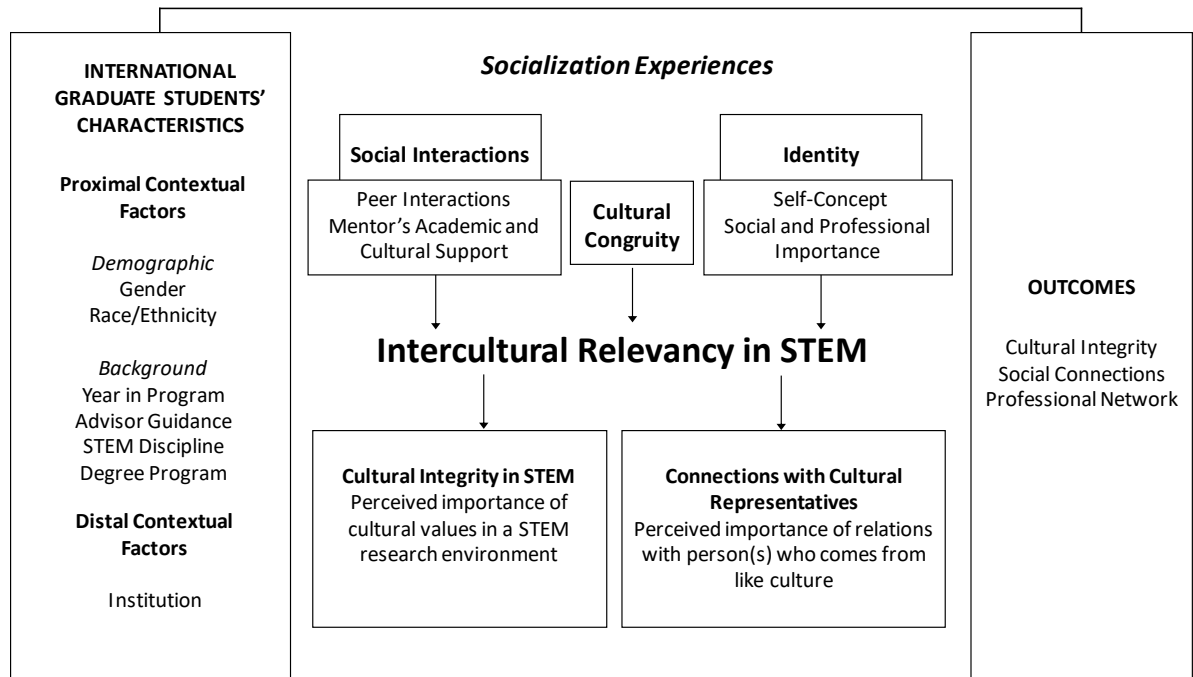


Figure 2.1. Intercultural socialization experiences.

Social Interactions

Other important factors of socialization include social interaction with research faculty mentor and peers. Some more recent studies found that mentor and peer relationships influence the retention and attrition of graduate students (Crede & Borrego, 2014; Golde, 2005; Lovitts, 2001). Social interaction is viewed as the social exchange between two or more people, such as the interaction and communication between a faculty mentor and mentee (Goffman, 1973). Symbolic interactionists refer to social interaction as social exchange that “can create the illusion of a shared social order despite not understanding each other fully and having differing perspectives” (Garfinkel, 1967; Understanding Social Interaction; Boundless Sociology, 2018).

Social interactions are ways we relate to others and how others relate to us.

Within the graduate education literature, advisor and mentor are terms that describe the nature of the relationship between a faculty supervisor and a graduate student (Barnes & Austin). Social interactions are investigated in this way as a mentor's cultural support and academic support, as well as peer interactions. Social interactions are based on typical graduate school experiences, the expected relationships, and some of the typical practices. Positive interactions between international graduate students and their faculty mentor and peers may further influence a person's socialization into the field and knowledge of the professional norms of that field.

The socialization of graduate students relies on students acquiring knowledge of the new profession and being able to see themselves as part of a new professional community (Flores, 2011; Gardner, 2008; Thornton & Nardi, 1975; Weidman, DeAngelo, & Bethea, 2014). International graduate students' ability to acquire knowledge and develop as part of a new professional community are inextricably linked the relationships and interactions they have with their mentors and peers (Glass, Kociolek, Wongtrirat, Lynch, & Cong, 2015; Hendrickson, Rosen, & Aune, 2011; Knox et al., 2013; Rose-Redwood & Rose-Redwood, 2013; Zhang & Goodson, 2011b). Therefore, these social interactions between international graduate students and their faculty mentors and peers are vital to successful socialization. Yet, international graduate students may experience these social interactions as a cultural exchange based on the different cultural backgrounds of the international graduate students, their mentors, and their peers. This study is interested in exploring how these social interactions between

international graduate students and their mentors and their peers inform the level of intercultural relevancy as part of the socialization process.

Previously in the counseling field, Schlosser and Gelso (2001) developed the Advisory Working Alliance Inventory (AWAI-S) to assess different elements of the advisor-advisee mentoring relationship. The AWAI-S measures three elements (Rapport, Identification–Individuation, and Apprenticeship) of the advisor-advisee mentoring relationship. Schlosser and Gelso (2001) found that positive advisory alliance was associated with students’ positive belief in their research competencies, optimism towards research, and also viewed their advisor as trustworthy and as an expert. The AWAI-S was one of the few instruments constructed to assess the advising relationship. Validity and reliability have since been established for use with graduate students in fields outside of counseling (Lunsford, 2012; Prime, Bernstein, Wilkins, & Bekki, 2014; Schlosser & Kahn, 2007). Rice et al. (2009) adopted the AWAI-S to learn more about international graduate students’ experiences in the United States. They surveyed 367 international graduate students at one research institution. This seminal study found that international students reported positive associations with their advisor as far as satisfaction, rapport, and professional mentoring. However, international graduate students’ advisory alliance ratings were lower than domestic U.S. students. Further, international students’ satisfaction with advising was highly associated with wanting to change advisors. Individual characteristics, such as students’ grade point average, gender, or college were slightly associated with advisory alliance ratings.

Social interaction is another integral aspect of socialization and assumes others are involved. These others can be advisors and peers who act as socialization agents in that they model the expected behaviors, values, and attitudes of the role of the specific department and the disciplinary home. Social interaction is considered a social exchange between two or more people (Kando, 1977). Graduate students engage in anticipatory socialization throughout their time in graduate school. In that while they prepare for their future professional role, they also practice behaviors akin to competencies expected in their future professional role. Usually, the discipline, program, and advisor determine the essential competencies. Activities provide opportunities to enact behaviors to prepare a person's readiness for the field. Though the implicit expectations and hidden norms that require translation, figuratively and literally, during their graduate studies has been heavily critiqued (J. J. Lee & Rice, 2007; Gregory & Lovitts, 2007; Walker et al., 2012). For example, anticipatory socialization activities can include learning the ways of a disciplinary field from an advisor, the time spent with others in the lab learning new skills, and the participation in professional development at conferences socialization.

My study has two primary demographic variables, including gender and race/ethnicity. I examine differences across racial groups on cultural integrity after accounting for all other explanatory variables. Rice et al. (2009) found no gender differences in the measured relationship. Another study on the advising experiences of women in STEM assessed the utility of the advising alliance for 293 women in STEM graduate programs. They found that a better type of alliance structure was more applicable to women. Instrumental support and psychosocial support were two factors

more salient for women in STEM (Prime et al., 2014). The AWAI-S findings informed the development of our mentor interaction scale, which included statements about cultural and academic aspects of their interaction. In my study mentor's cultural support is characterized by items such as 'My advisor is interested (engaged) in my culture' and 'Is tolerant about any cultural differences between us. Alternately, academic support items were represented as, 'My advisor is regularly available for advising.' Moreover 'My advisor meets with me to discuss research. Social interaction also involves connection and relationship to a network that introduces them to the larger scientific community in the United States (Terrazas-Carrillo et al., 2015). Consequently, international graduate students' perceptions of how their culture is received may inform the quality of their social interaction with an advisor or peer interaction in shaping their socialization experiences. Two important social interactions between international graduate students and their mentors are around cultural and academic support. The relationship (social exchanges) between an international graduate student and a mentor represents an intercultural exchange.

Mentor's Cultural Support. Mentor's cultural support is the extent to which a faculty mentor is interested in an advisee's cultural background and shows tolerance towards cultural differences. Mentor's cultural support is important to socialization. Positive intercultural relevancy shows personal relationship beyond the academic role and acknowledges international graduate students' responsibilities to family. A recognition and acknowledgement of cultural differences demonstrates respect. These ways of attending to the personal and cultural values are underestimated in the graduate

advisor-advisee relationship in STEM (Barnes & Austin, 2009a; Tincu, 2009).

Intercultural communications is positively associated with reduced cultural dissonance and therefore, a greater likelihood of success and connectedness (Gomes & Tran, 2017; Tran & Vu, 2017).

Mentor's Academic Support. The Carnegie Initiative on the Doctorate (CID) a research and action project that began in 2005 administered the Carnegie Foundation Survey of Doctoral students to 80 departments across the United States. The CID researchers examined the relationship between students' experiences in a doctoral program and the broader outcomes of doctoral education like increased doctoral completion rates and decreased time to degree (Golde & Walker, 2006). Survey results found advising behaviors adopted by faculty such as clarifying expectations in their advisor/advisee relationship can lead to improved student experience, less attrition, shorter time to degree and higher completion rates (Walker et al., 2012). Over the last 25 years empirically based studies on doctoral education critique communications between advisor and advisee as implicit (Gardner, 2007; Golde, 1998; Lovitts, 2007). Two key social interactions between international graduate students and their mentors pertain to cultural and academic support. These social exchanges between international graduate students and their faculty mentors represent an intercultural exchange and are instrumental to international graduate students' view of socialization experiences influence on intercultural relevancy in the STEM. Based on the extant literature, researchers Zhou and Golde (Zhao et al., 2007), Li and Gardner (2001), Lovitts (2007) and Gardner (2008) offer suggestions of specific advising practices that faculty can adapt

to positively enhance international graduate student professionalization and socialization process in STEM. For example, some of these practices include a writing support mechanism for international students and up to date visa policy support for travel to and from host country and nation of origin. Mentor's academic support of international graduate students relies on the ability of the advisor to communicate expectations of the degree, discipline, and the profession to the student. For international graduate students this communication represents a cultural exchange in which the mentors help international graduate students to navigate the new cultural environment of American higher education, the academic disciplines and the professional field; an environment that may be culturally different for the international graduate students' culture of origin. This study will explore the international graduate students' interactions with their mentors and how these interactions may influence the students' intercultural relevancy. Le and Gardner (2010) offer several recommendations for institutions and faculty to address graduate students' behavioral, emotional and cognitive development, which include: encourage peer interactions with each other and across departments; explicit communication; clarifying expectations; provide emotional support.

Peer Interactions. Peer interactions represent another important social exchange in the graduate socialization process (Floresh-Scott & Nerad, 2012). Other graduate students can play an important role in helping each other socialize to graduate school as well as to the discipline and the profession (Mwenda, 2010). For example, students can help each other in the lab, through collaboration and for personal support. For international graduate students these peer relationships have an additional function. International

graduate students can provide a cultural support for other international graduate students. Additionally, international graduate students who interact with U.S. students can engage in valuable cultural exchanges as a means to navigate potential cultural differences that emerge as part of the socialization process (Jairam & Kahl, 2012; Zhang & Goodson, 2011b). This study explores how these peer interactions influence international graduate students' levels of intercultural relevancy in STEM, and if these are positive or negative.

Social interaction is at the heart of socialization. Social interaction for graduate students is the act of becoming more active and engaged in their roles and responsibilities as graduate students and as emerging experts in the chosen academic field or discipline which is learned from others and themselves (Austin & McDaniels, 2006; Golde, 2005). For example, a graduate student who understands the communication style, expectations are clearly presented by her advisor, she sees herself as a novice researcher within the department. These elements of engagement can occur throughout the students' academic and social experiences (Johnson et al., 2017). Alternatively, if misunderstanding of signs and language occur in their social interaction an illusion of a shared meaning can still transpire unknowingly because of misunderstanding each other fully and differing perspectives (Garfinkel, 1979). This degree of misunderstanding and social isolation due to miscommunication whether it is between a faculty mentor or among peers can interfere with a healthy graduate school experience.

Cultural Congruity

Cultural congruity will play a role in how students perceive their value and worth within the research university and their disciplinary home. The term is adapted from a psycho-sociocultural (PSC) lens (Castellanos & Gloria, 2007; Gloria & Rodriguez, 2000) Psychological, social, and cultural dimensions are included in the investigation. The psychological describes self-beliefs and attitudes. The social dimension refers to relationships, interaction, and connection. The cultural dimension includes values and cultural perspectives. These three dimensions are important to examine collectively the experiences of international graduate students within the context of graduate school experiences (Castellanos & Gloria, 2007).

The meaning of cultural congruity is adapted from a psycho-sociocultural (PSC) lens (Gloria, Castellanos, & Herrera, 2016; Gloria & Robinson-Kurpius, 1996; Gloria & Rodriguez, 2000) in that there are three dimensions involved: psychological, social, and cultural. The psychological dimension encompasses internal beliefs and attitudes about self. The social aspect refers to relationships, interaction, and connection with others. Cultural dimensions address cultural values, norms, behaviors, and ways of knowing. The psychological, social, and cultural experiences of international graduate students within the context of graduate school are important to consider when examining collective (Gloria et al., 2016; Gloria, Castellanos, & Orozco, 2005). The construct of cultural congruity attempts to explain students' sense of cultural fit and the value and acceptance of their culture of origin by others (Brown & Robinson Kurpius, 1997; Gloria & Robinson-Kurpius, 1996). This study applies cultural congruity to understand the degree

international graduate students' cultural contributions and their social interactions in different cultural setting are related to intercultural relevancy. It is assumed that international graduate students who perceive others value and respect their culture will also value intercultural relevancy in STEM.

Research on cultural congruity has largely focused on Hispanic/Chicana/o, African American, and Native American racial groups at the undergraduate level (Brown & Robinson Kurpius, 1997; Gloria et al., 2016, 2005; Gloria & Robinson-Kurpius, 1996). A number of studies recommend more research in research that focuses on racialized groups and cultural fit at the graduate level and their experiences in STEM (Antony, 2002; Fries-Britt, Mwangi, & Peralta, 2014; Page-Reeves, Marin, Moffett, DeerInWater, & Medin, 2018; Seron, Silbey, Cech, & Rubineau, 2016; Suspitsyna, 2013). A fundamental assumption of cultural congruity is that a students' culture is a central component of who they are and how they interact with others. Cultural congruity expresses social-psychological aspects of cultural fit and measure the degree a person adjusts and feel valued in a new culture, such as American graduate school culture.

Identity

Self-concept is central to the international graduate students' interactions with their mentors and peers and subsequent socialization (Baker & Lattuca, 2010; Hall & Burns, 2009; McAlpine). The process of socialization and the relationships that international graduate students have with mentors and peers is inextricably linked with their understandings of "who they are, who they wish to be, and who they are becoming."

(Cotterall, 2015, p. 361). This study aims to understand the association that identity has with intercultural relevancy in STEM.

Questions about identity are integral to the students' socialization experiences. The experiences they bring, and the importance placed on identities, both professional and social, is assumed to affect how they will interact with others and the quality of those interactions. That is a student considers who they are and who they want to be personally and professionally.

To rationalize the social psychological view of identity, I provided a working definition that was influenced by sociologist Stone (1962). He asserts identity as where:

Almost all writers using the term imply that identity establishes *what* and *where* the person is in social terms. It is not a substitute word for “self” Instead when one has identity, he is situated – that is cast in the shape of a social object by the acknowledgement of his participation or membership in social relations. (p. 93)

Strauss argues identity formation is a lifelong process of re-conceptualizing self. The dynamic active process of identity formation continues over the course of a lifetime. New identities are revealed, and new realities experienced. Turning points and rites of passage are had to mark these new identities (situational, social, and personal).

Identity is not a substitute word for “self” instead many aspects of identity and social identity are used in this study to organize and categorize perceptions of self. According to Stets and Burke (2000), identity theory and social identity theory have similarities notable enough to link the two theories. In identity theory, the center of an identity is the “categorization of the self as an occupant of a role and the incorporation, into the self the meanings and expectations associated with that role and its performances.” (Stets & Burke, 2000, p. 225). For international graduate students who

have strong cultural identities, identity theory suggests that their background will play an important role for how they make meaning of their role as a graduate student as part of the socialization process (Chapdelaine & Alexitch, 2004; Yuefang Zhou et al., 2008).

Two important dimensions of identity for international graduate students is their personal and professional selves. Identity prominence is level of importance of an identity in the moment. Identity salience is understood as the probability that aspects of self will be invoked in distinct situations (Hogg, Terry & White, 1995). Hierarchical identity salience places importance on one identity over another in different social situations whereas identity prominence is the value an individual perceives of any given identity at any given point in time. Prominence is a more accurate measure for a cross sectional survey design used in this study. Research also finds interaction and perceived behavior of others may influence the prominence of an identity in a given environment and may be one of the reasons positive peer and advisor interactions are so critical (Floresh-Scott & Nerad, 2012; Noy & Ray, 2012; Tincu, 2009; Zhang & Goodson, 2011b). This current study focuses on two important aspects of international graduate students' identity prominence and how these identities may influence their socialization to STEM. These identities are professional and social as described next.

Identity prominence is operationalized through the professional and social identities that international graduate students have indicated are important to them. Identity theory is a central perspective this investigation holds. Identity formation is a reflexive process in which an individual develops through the roles they assume, the meanings of those roles, and the interactions that take place as part of a member of that

group. A person's professional and social and cultural identities are integral to the socialization process. Therefore, international graduate students' cultural and professional identities may influence how students perceive the socialization process (Weidman, Angelo, & Bethea, 2014). International graduate students' identities interrelate with their role as protégé and their anticipatory roles as a faculty member, Ph.D. in STEM, principal investigator or supervisor. These roles form expectations of how these peer and advisor relationships should look.

Fundamental to the socialization process is one's identity, both professional and social, students' understanding of these identities may influence how they navigate these experiences. Socialization in graduate school also involves intercultural connections and interaction with others such as a faculty mentor and one's peers. Further, these connections and interactions with their mentor, peers, and environment may be associated with how they view themselves. One assumption of this study is that these two broad dimensions of identity — social and professional — are central aspects of graduate student socialization and may change over the course of time spent in graduate studies.

Professional Identity. Commitment to a professional identity is located in the literature as being a primary contributor to successful transition to a career in STEM fields (Carlone & Johnson, 2007; Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011; O'Meara et al., 2014). Professional identity is defined as one's professional self-concept based on attributes, beliefs, values, motives, and experiences (Ibarra, 1999; Schein, 1978).

The significance of the departmental community in ensuring doctoral students' successful socialization has been explored by several researchers (Austin, 2002; Barnes & Randall, 2012). Community recognition is important to novice researchers (Carlone & Johnson, 2007). Englander (2009) argues that scholarly identity is transformed only when the identity of the novice researcher is recognized by 'legitimate' members of the community. Yet, many doctoral students feel invisible in their departments, particularly international students (Cotterall, 2015; Ingleton & Cadman, 2002). Perhaps culturally diverse students who have strong cultural identity and yet experience "otherness" rely on their professional identity to aid in the acculturation process (Cotterall, 2015; George et al., 2018; Gopaul & Pifer, 2016; Smith & Khawaja, 2011). The literature on graduate student socialization has historically not accounted enough for individual student differences (Antony 2002) and has been under-explored for culturally diverse students and other student subpopulations (Gardner, 2007). For those international graduate students who have strong professional identities, identity prominence could explain how the identity most relevant to each situation is relied upon in socialization. International graduate students' ability to navigate otherness that may arise due to the cultural dissonance and social isolation of the graduate school process play an important role for how they make meaning of their social identity as part of the socialization process.

Social Identity. Social identity theory asserts a person's knowledge that they belong to a group or social category. One aspect of identity theory most relevant to this study is the concept of role identity, which is where "persons adopt self-meanings and expectations to accompany the role as it relates to other roles in the group" (Stets &

Burke, 2000, p. 227). Social identity is an integral relational component to international graduate students' professional identity. The relationship between what is expected and what is reality of the experience for international graduate students is important to consider. As these expectations, of self and others, and the value placed on professional identity and social identity are negotiated, these perceptions of the experience both real or imagined may influence identity formation (Crede & Borrego, 2014; Marginson, 2013).

As people act to represent the group, they also hold the meanings and expectations of the group in interaction with others. With role-based identities meanings are negotiated and modified as one inhabits or performs a process of role acquisition in the socialization process.

The four important factors of socialization just outlined demonstrate a need to examine the intercultural aspects of socialization more closely to better understand international students' views of American graduate education in the U.S. (Zhang & Goodson, 2011b). Empirically less is known about international graduate students and the influence of intercultural aspects of socialization factors, such as, cultural congruity, social interaction, and the role of identity in graduate school (Kim, Collins, Rennick, & Edens, 2017; Kommers & Pham, 2016).

Contextual Factors

The graduate student socialization process is not uniform across disciplines. Year in program and degree are two background characteristics that indicate international graduate participants' positionality. Doctoral student development is theorized as

occurring in three distinct phases: entry, integration, and completion (Le & Gardner, 2010). As doctoral students develop and transition through these phases, the expectation is that they become more adept independent scholars in their fields (Le & Gardner, 2010; Tincu, 2009; Linlin Xu & Grant, 2017; Zhang & Goodson, 2011b; Yuefang Zhou et al., 2008). In this study, the work of Gardner and the model of doctoral student development she proposed influenced my interpretive lens. Throughout the study, I considered the unique differences among students' needs at different points of the graduate degree continuum. Previous research on doctoral student socialization use constant comparative methods to organize and interpret findings throughout the study as well as during the data analysis phase (Gardner, 2010a, 2010c; Gopaul, 2015; O'Meara, Knudsen, & Jones, 2013).

Both Golde (2005) and Gardner (2010) firmly establish that the disciplinary context and culture are crucial variables in the study of socialization. The discipline is the centrifugal force and locus of the doctoral student experience. In this study, the discipline, a control variable, is recognized as the term STEM discipline. The discipline categories in the survey are based on NSF's list of STEM disciplinary groupings, eventually organized by Biglan's four disciplinary typologies (Biglan, 1973a, 1973b). The disciplinary home for graduate students is the department. The department and institutional type are two other contexts influential in the socialization process (Gardner, 2010c; Golde, 2005). Gardner's (2009) research used departments' completion rates as a metric to determine the variance between departments. Even though department completion rates and the socialization experience at the department level is cited in the

literature as central to socialization important, it is not a factor used in this study. The institutional type categories used in this study are from the 2015 version of the Carnegie classification and include highest research universities (R1) and higher research universities (R2). These two institutional types have differential expectations for research, which in turn may influence the way in which a student is socialized in the department.

Chapter Two Summary: Literature Review

A major goal of this study was to determine the extent international graduate students' mentor and peer relationships, cultural fit, and identity formation influence intercultural relevancy as parts of the socialization process. The literature highlighted in this chapter indicate that relational aspects such as mentor and peer interactions, cultural fit, and self-concept effect cultural sense of belonging, integration and connection for international graduate students (Phelps, 2016; Rose-Redwood & Rose-Redwood, 2013; Todoran, 2018; Trice, 2004). The extent that intercultural relevancy in STEM is related to socialization is the main concern of the study. The intercultural propositions and how these were operationalized are described in Chapter Three. The levels of measurement and meaning of the variables are explained in more depth and linked to the methods. An advantage to embracing an intercultural lens is that it offers another way to analyze graduate student socialization. Intercultural notions run counter to assimilation and adaptation, which tend to dominate the theoretical landscape as featured components of traditional socialization theory. This study seeks to unveil more understanding about the

relationships between social relationships and self-concepts and if these more personal/softer emotional aspects of socialization are associated with cultural integrity and connection for international graduate students.

CHAPTER THREE

METHODOLOGY

Introduction

International graduate students are making important contributions to the global, national, and local economies in which they reside (Chien, 2013; Han & Appelbaum, 2016). These contributions are a result of their graduate educational experiences within American Higher Education. Therefore, it befits important stakeholders of American Higher Education to better understand more about international graduate students' experiences within the American public Research universities. Recent changes to U.S. immigration policies by the Trump's White House administration have led to unfavorable international views of the United States (Bhattacharyya, 2017; Dennis, 2017; Quilantan, 2018). The decline of international applications to graduate programs also give the U.S. cause for concern, especially the research universities that rely on international enrollment revenue. The loss of this revenue is catastrophic for many American public research universities as more international students decide to attend graduate school outside the U.S. (Dunlap, 2017; Glass & Lee, 2018; Bound, Braga, Khanna, & Turner, 2016; Redden, 2017).

Consequently, in this study I examine the influence of international graduate students' mentor support, peer interactions, cultural congruity, and identity prominence on intercultural relevancy in STEM at American public research universities.

International graduate students' perceptions of American Graduate Education establish

baseline understandings about the importance of intercultural experiences as they socialize to American Higher Education. Specifically, this main dependent variable as described below is intercultural relevancy. Intercultural relevancy is conceptualized as the degree of importance that cultural belonging has in STEM research environments and the value of connections with individuals who come from a similar national, ethnic, or cultural background. Intercultural relevancy is the latent construct for cultural integrity in STEM and connections to cultural representatives as richly described in Chapter Two. Cultural integrity in STEM and connections with cultural representative encompass relational aspects between one's cultural background and research choices in STEM, sense of belonging in the STEM environment, and the value of social connections with cultural representatives. Cultural representatives in this study refer to individuals who come from a graduate student's culture and who value their culture.

The social psychological lens of this study assumes that there are reciprocal relationships between self, others, and the environment — vis-à-vis academic environment (Stryker, 1968, 1980). This study explores the relationships between the international graduate students' perceptions of identity, relationships with peers and faculty, and intercultural relevancy as part of the socialization process. Also examined is the extent individual characteristics, and the institutional context contribute to explanatory insights and understandings about socialization experiences in STEM.

Of greater importance are the collective experiences of STEM international graduate students at American public research universities because a high percentage of them choose to matriculate at these institutions. In 2015, some 14,037 of international

graduate students earned a doctorate in Science and Engineering, which is up 30% since 2005, keep in mind this number has only increased by 2% since 2014. According to reports, 48 percent of the 14,037 internationals awarded doctorates wish to remain in the United States, and of those who remained in the U.S. would continue to contribute to the American knowledge economy (Han & Appelbaum, 2016; NSF, 2016). Empirical research about this essential population in graduate education studies has identified key areas where more research is needed to determine the association between some of the more nuanced aspects of the graduate school experience, such as cultural and social influence on persistence and success (George et al., 2018). Cultural perspectives can also bring deeper understandings to the topic of intercultural relevancy in graduate education and other socialization factors international graduate students encounter day to day in research environments at American public research universities (Chapdelaine & Alexitch, 2004; Feldon, Maher, & Timmerman, 2010). Like other culturally diverse groups, more understanding is needed about the degree of importance culture has on day to day relational interaction and its' influence on the nature of those relationships with a faculty mentor and peer colleagues within these settings (Merolla & Serpe, 2013; Merolla, Serpe, Stryker, & Schultz, 2012; Mwenda, 2010).

In this chapter, I begin by explaining the research design rationale and outline the research questions that guided my investigation. My role in the research process is stated with a description of the context and methods of the study. Details are described about the sampling approach and people who responded to the survey, including the characteristics of each participating institution, and the data collection procedures. Next, I

summarize the characteristics of the instrument such as, the scale items and the levels of measurement of the foci variables. The analytical approach and the preparation of the survey data for analyses is explained. Each research question is aligned with the planned statistical analysis. The results from the tests of reliability and validity of the measures determined the analytic approach for each research question.

Research Design

A quantitative research design was chosen to examine the influence of international graduate students' mentor and peer relationships, cultural fit, and identity on intercultural relevancy in STEM as parts of the socialization process. The broadly conceived socialization process is operationalized by students' social interactions with faculty mentor and peers, cultural congruity, identity prominence, and intercultural relevancy in STEM. Social interactions are conceptualized as mentor's cultural and academic support and peer interactions. The second construct under study is cultural congruity. Cultural congruity is defined as an individual's sense of cultural belonging and fit with the values of the university (Gloria & Robinson-Kurpius, 1996). The third construct, identity prominence signifies the level of importance that is placed on one's professional and social identities (Brenner, Serpe, & Stryker, 2014). I determined the possible associations between these factors and intercultural relevancy as parts of socialization process through a model building approach using ordinary least squares regression (OLS).

Research Questions

The following research questions are addressed:

1. To what extent do international graduate students' social interactions with their faculty mentors and peers influence their intercultural relevancy in STEM?
2. To what extent do international graduate students' levels of cultural congruity influence their intercultural relevancy in STEM?
3. To what extent do international graduate students' strong professional and social identity positively influence their intercultural relevancy in STEM?

These research questions will be analyzed using a strong set of control variables that have been shown to influence the graduate experience including individual characteristics like gender and ethnicity, year in program, STEM discipline, advisor guidance, degree program, and institutional type (Bair & Haworth, 2005; Borrego, Knight, & Choe, 2017; Gardner, 2010c; Golde, 2005; E. Zhou & Okahana, 2016).

Role of the Researcher

As a researcher, relaying my positionality is relevant to this quantitative study that explores international graduate students' understandings of their STEM graduate school interactions. As a critical researcher and scholar of graduate education, the research process presents ethical challenges such as maintaining confidential when reporting on graduate school structures and students' experiences. My intent on sharing international graduate students' perceptions of their social interactions and the degree of importance culture and identity play in the STEM context may provide a more informed lens for

graduate school stakeholders who review and implement practices and policies at research universities that impact international graduate students' realities. I interpret the data based on measures developed by U.S. researchers to understand students' perceptions of cultural congruity and institutional fit in graduate school with a degree of skepticism. Linguistic interpretations and understandings of culture and identity are broadly defined, however institutional features and essential relationships can be more defined more systematically. These findings are the first phase of understanding international graduate students' interpretation of graduate school in the U.S. context at research universities. My motivation to do this research comes from a need to understand and convey some lesser known dynamics about what international graduate students experience in the STEM fields at American public research universities. As a researcher, my paramount obligations are to the institutions and students who elected to participate in this research study. Being entrusted with their views of the graduate school experience, may lead to greater insights for those of us who strive to make higher education more culturally attuned. Given the existing differences across racial groups, a within group analysis can determine if differences exist among heterogeneous characteristics of this diverse population of international graduate students. International students are often treated as a homogenous group and compared to domestic students. The selection of a within group analysis to investigate the macro power structures embedded in STEM graduate education was intentional.

The queries of this study arise from a deep interest in better understanding and relaying international graduate students' experience. My existing relationships with

graduate students and direct engagement with research groups and institutional transformation efforts present unique challenges and responsibilities. First, I need to convey the survey research context of this study and subsequent findings on international graduate students' experiences at American public research universities with integrity while also acknowledging the inherent ambiguity of that process. Being an emerging researcher of graduate education awards certain privileges, such as frequent interaction with other graduate students. These interactions with graduate students throughout my doctoral process allowed me certain privileges. I concede these experiences have led to certain assumptions about the graduate experience that needed to be interrogated. These new understandings happened over the course of my time as a graduate student and do inform the interpretations drawn from the survey data of this study.

My role in this research is important for the reader to know because of my involvement as a social science researcher for the Pacific Northwest Circle of Success: Mentoring Opportunities in STEM (PNW-COSMOS) program, an NSF AGEP-T, see Appendix B. I participated in the development of the survey. Prior to my work as a researcher on the project I served as an administrator of graduate education programs where I was responsible for recruitment, retention, and completion activities for Indigenous populations. Over the last 12 years, my work and personal relationships with Indigenous graduate students has informed my worldview substantially and day to day interactions with graduate students. The research process unmasked multiple assumptions I held regarding international students' experiences of their culture and the host country's cultural norms during graduate school. To address my inclination towards supposing

Indigenous views of STEM culture were comparable to internationals, I had to distinguish international views from what I knew of Indigenous perspectives and plunge into the literature regarding international students and intercultural studies.

The relationship of an intercultural perspective and identity theory to explain socialization can be strengthened through critical quantitative methods. The critical quantitative approach incorporates three intentional actions. First, researchers attend to the development of judicious research questions. Second, respect the community of people the research concerns by choosing appropriate research practices and constructs. Third, the researcher aims to advocate for equal opportunities for all people (Leahy, 2008; Rios-Aguilar Cecilia, 2015; Stage, 2007). My procedures were influenced by this method in that the theories I use to explore the data on this unique population are underutilized. The survey constructs were created using theoretical and empirical research: intercultural perspectives (Guillory & Wolverton, 2008; Museus & Quaye, 2009; Shotton, Oosahwe, & Cintrón, 2007), cultural congruity (Gloria & Robinson-Kurpius, 1996), mentor (Guillory & Wolverton, 2008; Museus & Quaye, 2009; Prime et al., 2014) and peer interaction (Pascarella & Terenzini, 1980), identity prominence (Carlone & Johnson, 2007; Chemers et al., 2011; Phinney, 1992; Stryker & Serpe, 1994). I revised the research questions several times to reflect the constructs understudy more accurately and were expanded to include 6 questions to reflect the two outcome variables: cultural integrity in STEM and connections with cultural representatives.

Sampling Approach

This study relied on 953 international graduate students' responses to the PNW-COSMOS Graduate Students' Experiences (GSE) survey administered in 2015-2017 by the Social Science Research Group of the PNW-COSMOS, a National Science Foundation funded grant. A cross-sectional survey research design was used to collect data from graduate students at the masters and doctoral level matriculated in STEM degree programs at 12 research universities located in the Mountain (4), Pacific (2), West North Central (1) and the West South Central (2) regions of the United States (U.S. Census Bureau, 2018). Universities were selected based on three criteria: demonstrated success with the recruitment and retention of diverse students, classified as research doctoral institutions: six Highest Research (R1) activity and six Higher Research activity (R2) and had graduate instructional programs. Graduate instructional programs are classified by Carnegie as STEM Dominant (STEM/D), comprehensive programs without medical and veterinary school (CP), and comprehensive programs with medical and veterinary school (CP/Med/Vet).

Population

The population of interest for this study is international graduate students in STEM at research universities in the U.S. The population includes students in STEM programs recognized by the National Science Foundation. We excluded the social and behavioral science programs from the study. For the full list of NSF STEM discipline programs considered see Appendix D. The population that is accessible to this study

consisted of all persons who were current graduate students of STEM programs, at 12 research universities between the fall of 2015 and the spring of 2017. Research universities recruited for the study met those criteria.

The sampling frame was obtained from the Graduate Student Experiences survey of the PNW-COSMOS Social Science Research Group. A census sample method was used because of the large number of graduate students who matriculate at research universities each year, and for this study a subsample of all international graduate students who participated was chosen for inclusion in this study's analysis. This resulted in a sample size of 1,085 persons from 12 research universities over the two-year duration of the study. The size estimate for the international graduate student population in STEM at these institutions is 6,350 at the 12 institutions. The total number of international graduate students who responded to the survey was 1,085, with an overall response rate of 17%, see Table 3.1. The study sample was drawn from a representative population of international graduate students who attend public research universities. However, there is still a chance I have sample bias based on non-responders. Given the population of 6,350, confidence level of 95%, a confidence interval of 5, I need at least 362 students in my final sample, which was met. I tolerated a margin of error, $\pm 3\%$, a confidence error of 95% for a representative sample size (Creswell, 2009; Fowler, 2002). The GSE survey's census sampling approach allowed the research group to contact all graduate students in STEM at each institution. Contact was made through student email addresses provided by a representative from each graduate school (e.g., administrator, dean, or institutional researcher). The census sampling method falls short of a random

sampling. However, the final sample of participants met and exceeded the threshold of 362 ($n = 953$). For survey research this study has a large sample, especially compared to other studies concerning this population, however it is not a random sample. Though I did inflate the estimate of the participating institutions' populations, this study can be considered representative of the population (Field, 2009).

For this study, I delimited the sample to the 1,085 international graduate students who responded to the PNW-COSMOS GSE survey. The sample includes those students who were considered enrolled at the time the survey was administrated at 12 public research universities. After I removed missing data systematically, I further delimited the sample to only the students who had complete data on all the study variables (Downey & King, 1998). This action decreased the sample size by 12% of international graduate students ($n = 953$) who were included in the final sampling frame. Given the estimated population of international graduate students in STEM at the 12 institutions, the final response rate is at an acceptable 17% (Alreck & Settle, 2004; Mills & Gay, 2011). The final sampling frame of the study included all international graduate students who responded to the survey, which is 1,085. The final analytical subsample from the original sampling frame contained 953 international graduate students survey respondents.

Table 3.1. Survey response rate by institution and research university comparison of institution population, 2015:
Total numbers of full-time graduate students and International graduate students in STEM, and Health.

Comparison of Research University Population, 2015				Survey Response Rate		
University	IG students <i>Total #s in STEM, & health</i>	GS students <i>Total #s in STEM, & health</i>	IG students at each campus %	Total # Emails Sent	University Overall Response Rate %	IG students Response Rate %
Univ1**	180	794	24%	817	252 (31%)	56 (31%)
Univ2**	64	520	9%	318	168 (53%)	34 (11%)
Univ3**	97	645	24%	305	305 (29%)	41 (4%)
4NA	NA	NA	42%	125	51 (42%)	NA
Univ5*	773	1,534	38%	1,324	266 (21%)	106 (14%)
Univ6**	997	1,871	47%	409	317 (00%)	134 (13%)
Univ7*	938	2,317	32%	1,772	623 (35%)	173 (18%)
Univ8*	656	1,315	46%	1,320	433 (32%)	140 (21%)
Univ9*	645	1,203	35%	1,769	578 (33%)	181 (28%)
Univ10**	75	309	23%	159	70 (44%)	21 (28%)
Univ11**	66	607	10%	383	130 (34%)	15 (23%)
Univ12*	793	1,509	37%	2,099	309 (15%)	80 (10%)
Univ13*	1,066	3,194	31%	2,109	510 (23%)	104 (10%)
TOTAL	6,350	16,561		12,889	4,012	1,085(17%)

Note: Data sources - National Science Foundation, National Center for Science and Engineering Statistics, Survey of Graduate Students and Post doctorates in Science and Engineering and the PNW-COSMOS Social Science Research Group. Population numbers include full time and part time.

Broad understanding about international graduate students' participation in STEM can be drawn from the Survey of Earned Doctorates. The 2016 annual report shows international graduate students represent the majority in the following STEM degree programs: electrical engineering and petroleum engineering (81%), computer science (79%), industrial engineering (75%), statistics (69%), mechanical engineering and economics, statistics (63%), civil engineering (59%) and chemical engineering (57%) (Anderson, 2017; National Foundation for American Policy, 2017; National Science Foundation National Center for Science and Engineering Statistics, 2018).

Characteristics of Participants

The demographic and background characteristics of the international graduate student participants included in the final analytical sample are illustrated in Table 3.2. There are two self-reported items, gender and race/ethnicity, that represent demographic characteristics of survey participants. Of the international graduate student sample ($n = 953$), males account for 62% ($n = 597$) and females 38% ($n = 356$). Asian/Pacific Islander students (66.4%) represent the largest group ($n = 633$). This number is to be expected as the highest numbers of people who apply and come to the U.S. for graduate school come from Asian countries (National Science Board, 2016, 2018; Roksa, Jeong, Feldon, & Maher, 2018). Indian and East Asian as a distinct category was excluded from the survey and falls under the Asian/Pacific Islander category. This demographic coding limitation could also explain why Asian/Pacific Islander students make up the largest group in the sample. The second highest group represented is White/Caucasian (9.2%), closely followed by Hispanic/Latino/a (8.3%) and Arab Middle Easterner (6.5%) racial groups.

The least represented racial group is Black/African (3.4%). The last race and ethnicity category students could self-identity is Other (6.1%). A much larger proportion of students are seeking Doctoral degrees (73%) than Master's degrees (27.2%). The nine items of the STEM discipline category were recoded into Biglan's four disciplinary typologies. The disciplinary typology that makes up the highest proportion of the sample is Applied, Non-Life, Hard (i.e., engineering) at 51.5%, followed by Pure, Non-Life, Hard (i.e., physics, chemistry) at 24.3% respectively, and then Pure, Life, Hard (e.g., botany, biology). The least represented disciplinary typology is Applied, Life, Hard (i.e. agricultural sciences) at 4.6%. An overview of the sample characteristics for comparison are in Table 3.2. For more detailed information on the National Science Foundation classification of STEM disciplines and Biglan's four disciplinary typologies (Biglan, 1973a, 1973b) see Appendix D.

Table 3.2. Characteristics of International Graduate Student Participants (n = 953).

Twelve Doctoral Universities	Total n	Percent of Respondents
<i>Gender</i>		
Male	597	62.6%
Female	356	37.4%
<i>Race/Ethnicity</i>		
Arab/Middle Eastern	62	6.5%
Asian/Pacific Islander	633	66.4%
Black/African	32	3.4%
Hispanic/Latino/a	79	8.3%
White/Caucasian	88	9.2%
Other	59	6.2%
<i>Year in Program</i>		
1st Year	302	31.7%
2 nd Year	253	26.6%
3 rd Year	134	14.1%
4 th Year	128	13.4%
5 th Year	92	9.7%
Over 6 years	44	4.6%
<i>STEM Discipline*</i>		
Pure, Life, Hard	182	19.1%
Pure, Non-Life, Hard	233	24.5%
Applied, Life, Hard	44	4.6%
Applied, Non-Life, Hard	494	51.8%
<i>Degree Program</i>		
Doctoral	694	72.8%
Master's	259	27.2%

The 12 participating institutions were categorized by its institutional type as defined by the Carnegie Commission on Higher Education. The two categories of institutional types represented in this study were Highest Research Activity, R1 (76.3%) and Higher Research Activity, R2 (23.7%) shown in Table 3.3.

Table 3.3 Institutional context, number and percentage of international graduate students by Basic Carnegie Classification

Institutional Type	Total n	Percent of Respondents
R1	226	23.71%
R2	727	76.29%
Total	953	100%

Table 3.4 shows each institutional classification and other characteristics. Institutions with a community engagement (CE) classification are also acknowledged. The total enrollment for the 12 institutions ranged from 10,267 to 43,751. In turn, research expenditures differed across institutions and ranged from \$ 25,864 to \$ 604,464.

The Carnegie Classification of Institutions[®] has been the most commonly used system for categorizing and describing existing differences and commonalities of American colleges and universities. The classification assigned to an institution is based on the level of degree awarded and the disciplinary area in which the degree is earned. Further, student enrollment numbers, admissions selectivity, and the amount of federal research monies awarded also contribute to the basic classification of an institution. This study assumes the 2015 definition and classification of doctoral universities. According to the 2015 Carnegie Classification of Institutions[®] doctoral universities are categorized as highest research universities, higher research universities, and moderate research universities (The Carnegie Classification of Institutions of Higher Education, n.d.). A comparison of institutional characteristics shows distinct differences between R1 and R2 institutional types. Institutional type was used as a control variable to account for these institutional differences such as size and degrees conferred.

Table 3.4. Participating research universities' characteristics and classifications.

Institution	GIP*/CE*	Total Research Expenditures 2016	Total Enrollment 2017	% of Pell Grant	% Minority
Univ1**	STEM/D, CE	102,457	12,072	32%	11%
Univ2**	STEM/D, CE	70,059	11,865	34%	13%
Univ3**	STEM/D, CE	112,073	16,613	24%	9%
Univ4 NA	NA	NA	NA	NA	NA
Univ5*	CP/Med/Vet, NC	334,082	30,614	31%	26%
Univ6**	CP/Med/Vet, CE	183,799	25,295	28%	27%
Univ7*	CP/Med/Vet, CE	350,212	32,800	27%	18%
Univ8*	CP/Med/Vet, CE	193,254	22,795	56%	23%
Univ9*	CP, NC	152,233	23,279	57%	48%
Univ10**	CP/Med/Vet, NC	25,864	10,267	23%	12%
Univ11**	CP, NC	39,580	31,051	35%	38%
Univ12*	CP/Med/Vet, NC	259,998	28,527	22%	27%
Univ13*	CP/Med/Vet, NC	604,464	43,751	26%	37%

SOURCE: IPEDS, National Science Foundation, National Center for Science and Engineering Statistics, Survey of Graduate Students and Post doctorates in Science and Engineering, Minority includes American Indian/Alaska Native, Black or African American, Hispanic/Latino/a, Native Hawaiian or Other Pacific Islander, Two or More Races.

NA, participant responses from this university are excluded from this study.

Basic Carnegie Classification = BCC

R1*: Doctoral Universities – Highest research activity R2**: Doctoral Universities – Higher research activity

Community Engagement = CE, Community Engagement Not Classified = CE/NC

Graduate Instructional Program = GIP

STEM/Dominant = STEM/D, Comprehensive programs, with medical/veterinary school = CP/Med/Vet, Comprehensive programs, no medical/veterinary school = CP

Most research on graduate students has focused on elite institutions. This study is unique as the context focuses on two types of public research universities. For example, the smaller size of R2 institutions may contribute to more time with faculty mentor as labs tend to have less students, versus R1 institutions that are larger in size, and therefore have higher number of students and less individual attention from a faculty mentor.

Higher education research studies and this study uses the Carnegie Classification and NSF's Survey of Earned Doctorate and NCES data to control for institutional differences. As the only institutional control it influences the interpretation of this study's findings, and to ensure accurate representation of this sample of students (Indiana University Center for Postsecondary Research, n.d.; The Carnegie Classification of Institutions of Higher Education, n.d.)

Instrument

The PNW-COSMOS Graduate Student Experience survey was designed to examine the socialization experiences of different racial and ethnic graduate students in STEM. The survey instrument design was guided by the Total Design Method (Dillman, Smyth & Christian, 2009) to ensure rigor and reliability during all aspects of data collection and analysis. The full instrument is comprised of 10 composite scales, created from the sum of the variable values of the scale. The survey had a total of 40 questions, for the full instrument see Appendix C. The PNW-COSMOS GSE survey instrument was constructed and validated in 2015 by the PNW-COSMOS Social Science Research Group (SSRG). The constructs of the survey were validated based on the entire sample of survey

participants including national and international graduate students in STEM ($N = 4,012$). This initial validation of survey items resulted in the following reliability measures in the variables used in this study. These five scales initially included Intercultural Relevancy in STEM (8 items) ($\alpha=.78$), Mentor Interactions (10 items) ($\alpha=.92$), Peer Interactions (7 items) ($\alpha=.87$), Cultural Congruity (9 items) ($\alpha=.81$), and Identity Prominence (6 items) ($\alpha=.76$). These measures were further validated using the subsample of international graduate students ($n = 953$) as described in the “Data Analysis” section below.

International status was determined by two measures. The first is an item on the survey called “Present citizenship status”, a categorical dichotomous scale, with U.S. citizen and citizen of another country.

Table 3.5 and Table 3.6 display the study variables, level of measurement, and survey items that make up each construct and variable. The first self-reported category collected was the students’ race and ethnicity. Table 3.5 presents the categorical scales for demographic variables (race/ethnicity and gender). The racial/ethnicity variable with six ethnic/racial categories was recoded into six polytomous dummy variables:

“Arab/Middle Easterner” (1 = yes ; 0 = no); “Asian/Pacific Islander” (1 = yes ; 0 = no);

“Black/African” (1 = yes; 0 = no); “Hispanic/Latino/a ” (1 = yes; 0 = no);

White/Caucasian” (1 = yes; 0 = no); and “Other” (1 = yes ; 0 = no). The “Other”

race/ethnicity category includes those students who self-reported race unknown. The

gender categories include “male” (1 = yes ; 0 =no) and “female” (1 = yes ; 0 = no). The

people that self-selected the “Other” category for gender were subsequently removed due to the low number of cases.

Table 3.5. Demographics characteristics: A list of the control study variables and their levels of measurement.

Variables	Coding/Value	Data Type
Gender (sex)	1 = Female 0 = Male	Categorical, Dichotomous
Race/Ethnicity	1 = Arab/Middle Eastern 2 = Asian/Pacific Islander 3 = Black/African 5 = Hispanic/Latina/o 8 = White/Caucasian 9 = Other	Categorical, Polytomous

The background characteristic variables (year in program, advisor guidance, (STEM discipline, and degree program) and the institutional variable (institutional type) are illustrated in Table 3.6. Two more background characteristics were recoded, the advisor guidance item as “seeks advisor guidance” (1 = yes; 0 = no); and “does not seek advisor guidance (1 = yes ; 0 = no) and degree type item as master's Degree (1 = yes ; 0 = no) and doctoral degree (1 = yes ; 0 = no). The students’ STEM discipline were collapsed into the four categories of Biglan’s model on disciplinary contexts: 1. pure-life-hard, 2. pure-non-life-hard, 3. applied-life-hard, and 4. applied -non-life- hard (Biglan, 1973a, 1973b) and dummy variables were created: “pure, life, hard” (1 = yes ; 0 = no); “pure, non-life, hard” (1 = yes ; 0 = no); “applied, life, hard” (1 = yes ; 0 = no); and “applied, non-life, hard” (1 = yes ; 0 = no). The 12 institutions were dummy coded as: R1: doctoral universities – highest research activity (1 = yes; 0 = no) and R2: doctoral universities – higher research activity (1 = yes; 0 = no).

A pseudonym was given to each institution to protect the identity of participating institutions. Due to the high number of participating institutions and the even number of

institutional types represented, I collapsed the 12 institutions into two categories for two reasons. The first reason is technical in that too many levels could negatively impact the data analysis. The second is theoretical, there are few quantitative studies on graduate students that include both R1 and R2 institutional types as separate and in differential terms. The institutional type that awards doctoral degrees is defined by the Basic Carnegie Classification of American Colleges and Universities as R1: doctoral universities – highest research activity, R2: doctoral universities – higher research activity, and R3: doctoral universities – moderate research activity. This classification is assigned to institutions that awarded at least 20 research or scholarship doctoral degrees during the update year, excluding professional practice doctoral-level degrees, such as the JD, MD, PharmD, DPT, etc.

Table 3.6. Background and institutional characteristics: A list of the control variables and their levels of measurement.

Variables	Coding/Value	Data Type	Meaning Items
Advisor Guidance	0 = No 1 = Yes	Categorical, Dichotomous	
Year in Program	1 = 1st Year 2 = 2nd Year 3 = 3rd Year 4 = 4th Year 5 = 5th Year 6 = Over 6 Years	Ordinal	
STEM Discipline	1 = Environmental Science 1 = Life/Biological Sciences 2 = Chemistry 2 = Geosciences 2 = Mathematics 2 = Physics/Astronomy 3 = Agricultural Sciences 4 = Computer Science 4 = Engineering	Categorical	Biglan's Four Disciplinary Typologies 1 = Pure, Life, Hard 2 = Pure, Non-Life, Hard 3 = Applied, Life, Hard 4 = Applied, Non-Life, Hard
Degree Program	0 = Doctoral 1 = Master's	Categorical, Dichotomous	
Institutional Type	0 = Univ 1 0 = Univ 2 0 = Univ 3 NA = Univ 4 1 = Univ 5 0 = Univ 6 1 = Univ 7 1 = Univ 8 1 = Univ 9 0 = Univ 10 0 = Univ 11 1 = Univ 12 1 = Univ 13	Categorical, Dichotomous	0 = R2: Doctoral Universities – Higher research activity 1 = R1: Doctoral Universities – Highest research activity

Outcome Variables

Intercultural Relevancy in STEM

The Intercultural Relevancy in STEM items were developed by the Social Science Research Group but were informed by the intercultural framework and propositions of Kuh and Love (2001) and Museus and Quaye (2009). As a result of the factor analysis, the original 8 item Intercultural Relevancy in STEM construct was reduced and operationalized into two outcome variables: cultural integrity in STEM and connections to cultural representatives. Based on the factor analysis, which is described below, Cultural integrity is defined as students' perception of culture in relation to their academic experiences and the STEM environment. Connections to cultural representatives is defined as the degree to which students identify with individuals on campus with shared beliefs and cultural understandings. Intercultural relevancy in STEM measures the importance of cultural background and research choices, sense of belonging in the STEM environment, and social connections with cultural representatives' students report. Cultural representatives are defined as individuals who come from a graduate student's culture and who value their culture.

Cultural Integrity in STEM. The first 4 items were measured on a 5-point Likert scale where 1 = Strongly Agree and 5 = Strongly Disagree. Each variable needed to be reverse coded to reflect that higher levels on the index which suggests they strongly agree to the following statements: "My experiences in STEM are shaped by my cultural meaning systems.". "I have a strong cultural identity that guides the meanings that I

attach to my interest in STEM”, and “It is important for me to see how my culture of origin aligns with the STEM environment.” These 4 items measure the extent that a respondent’s cultural background influences how they view their experiences in STEM and the degree in which it fits in the STEM environment, these items indicate levels of agreement towards the importance cultural integrity in STEM, see Table 3.7. In the final scale the outcome variable, cultural integrity in STEM, became a composite index from three validated items in the Intercultural Relevancy in STEM scale.

Connections with Cultural Representatives. The second outcome variable measures perceptions about the value of cultural representatives in the graduate education milieu. It is continuous interval scale that includes three items about beliefs regarding the graduate experience and connections with cultural representatives. The three items were measured on a 5-point Likert scale where 1 = Strongly Agree and 5 = Strongly Disagree. These three items are worded in a theoretically detached tone. Cultural representatives are defined on the survey as people who identify with the same culture and share the same beliefs and customs. Cultural representatives are individuals from a similar cultural background. Just before these items, the survey provided a definition that read, “Cultural representatives are defined as individuals who come from a graduate student’s culture and who value their culture.”. This scale measures students’ level of agreement to the following statements: “The extent that individuals appreciate a graduate student’s culture of origin can reduce the amount of cultural conflict experienced by the student, which can increase the student’s persistence.”, “The quality and quantity of a graduate student’s connections with various cultural representatives on their own campuses is positively

associated with their likelihood of persistence.”, and “Graduate students are more likely to persist if cultural representatives emphasize educational achievement, educational attainment, value, and cultural heritage.” These items come from the propositions of the intercultural framework developed by Museus and Quaye (2009), a theory that builds on and advances Kuh and Love's (2000) cultural perspective of college student departure are shown in Table 3.7.

Table 3.7. Outcome Variables and their levels of measurement.

Outcome Variables	Coding	Level of Measurement	Item
DV1 Cultural Integrity in STEM	1 = Strongly Disagree 2 = 3 = 4 = 5 = Strongly Agree	Interval, 5-point Likert scale	- My experiences in STEM are shaped by my cultural meaning systems. - I have a strong cultural identity that guides the meanings that I attach to my interest in STEM. - It is important for me to see how my culture of origin aligns with the STEM environment. - I experience very few cultural conflicts with my STEM education.
DV2 Connections with Cultural Representatives (8 items)	1 = Strongly Disagree 2 = 3 = 4 = 5 = Strongly Agree	Interval, 5-point Likert scale	- Graduate students who experience cultural conflict must adjust to the dominant culture on the campus or have good connections at their university with cultural representatives to be persistent. - The extent that individuals appreciate a graduate student's culture of origin can reduce the amount of cultural conflict experienced by the student, which can increase the student's persistence. - The quality and quantity of a graduate student's connections with various cultural representatives on their own campuses is positively associated with their likelihood of persistence. - Graduate students are more likely to persist if cultural representatives emphasize educational achievement, educational attainment, value, and cultural heritage.

Explanatory Variables

Social Interactions

The social interaction indices are operationalized using cultural mentor's support, mentor's academic support, and peer interaction scales. The social interaction indices draws from 3 latent constructs: mentor's cultural support, mentor's academic support, and peer interaction. It is a self-report measure that reports the perceived quality of the advisor and advisee working relationship and peer-group interaction. The social interaction indices are categorized as a latent construct based on the literature on graduate students' experiences and is operationalized using the following observed variables, Mentor's Cultural Support (5 items), Mentor Advising (5 items), and Peer Interaction (7 items).

Mentor's Cultural Support. Mentor's cultural support is a five-item scale asking respondents to rate the extent to which their mentor is interested in their culture, is tolerant of cultural differences, is interested in their academic contributions. The items were measured based on a 5-point Likert scale where 1 = Strongly Disagree and 5 = Strongly Agree and higher scorers report greater levels cultural support from their mentor. The content of these items was influenced by empirical research on American Indian students and female graduate students in science and engineering (Guillory & Wolverton, 2008; Museus & Quaye, 2009; Prime et al., 2014; Shotton et al., 2007).

Mentor's Academic Support. Mentor's academic support is a five-item scale asking respondents to rate the extent to which their mentor provides them timely

feedback, clear expectations, and talks to them about their work. The items were measured based on a 5-point Likert scale where 1= Strongly Disagree and 5=Strongly Agree and higher scorers report greater levels Mentor support. This scale uses measures developed by Pascarella and Terenzini (1980).

Peer Interactions. Peer Interactions is a seven-item scale asking respondents to rate the ease with which they were able to make friends, the interpersonal relationships that they have developed on campus, whether peers on campus would listen to them if they had a personal problem, and the impact that being on campus has on the likelihood that they would attend a multicultural event. The items were measured based on a 5-point Likert scale where 1 = Strongly Disagree and 5 = Strongly Agree and higher scorers report greater levels of connection to their peers. The scale uses measures developed by Pascarella and Terenzini (1980). Table 3.8 presents the cultural congruity items and levels of measurement.

Table 3.8. Social interactions: A list of the study variables and their levels of measurement.

Explanatory Variables	Coding	Levels of Measurement	Item Description
Mentor's Cultural Support (5-items)	1 = Strongly Disagree 2 = 3 = 4 = 5 = Strongly Agree	Interval, 5-point Likert scale	○ Is interested (engaged) in my culture. ○ Is interested in me beyond my academic role (what I can contribute academically.) ○ Is tolerant about any cultural differences between us. ○ Appreciates cultural diversity. ○ Is friendly towards my family.
Mentor's Academic Support (5 items)	1 = Strongly Disagree 2 = 3 = 4 = 5 = Strongly Agree	Interval 5-point Likert scale	○ Is regularly available for advising. ○ Meets with me to discuss research. ○ Is interested in my goals and projects. ○ Provides constructive criticism on my project/research. ○ Returns my work in a timely manner.
Peer Interactions (7 items)	1 = Strongly Disagree 2 = 3 = 4 = 5 = Strongly Agree	Interval 5-point Likert scale	○ Since coming to this university, I have developed close personal relationships with other students. ○ The student friendships I have developed at this university have been personally satisfying. ○ My interpersonal relationships with other students have had a positive influence on my personal growth, attitudes, and values. ○ My interpersonal relationships with other students have had a positive influence on my intellectual growth and interests in ideas. ○ It has been difficult for me to meet and make friends with other students. ○ Students would be willing to listen to me and help if I had personal problems. ○ I am more likely to attend a cultural event (for example, a concert, lecture, or art show) now than I was before coming to this university.

Cultural Congruity. The Cultural Congruity scale measures international graduate students' perceived value of their culture in the new environment, alignment between new culture and culture of origin, and how well the university supports the unique needs of international graduate students. The Cultural Congruity scale has a total of 9 items, 7 of these items are reverse-scored. Higher scores indicate increased sense of cultural congruity and that students can leverage their culture in their academic and social experiences in STEM. The items were measured using a 7-point scale, where 1 = Not at All True and 7 = Very True. For this study, cultural congruity is defined as the fit of an individual's internal value with those values of the university as cultural congruity (Gloria and Robinson Kurpius, 1996). Table 3.9 presents the cultural congruity items and description of measurement levels.

Table 3.9. Cultural congruity: A list of the study variables and their levels of measurement.

Explanatory Variable	Coding	Level of Measurement	Item Description
Cultural Congruity (9 items)	1 = Not at All True 2 = 3 = 4 = 5 = 6 = 7 = Very True (reverse scored)	Interval, 7-point Likert scale	○ I feel that I have to change myself to fit in. ○ I try not to show the people around me who I really am. ○ I often feel like a chameleon, having to change who I am depending on the person I am with. ○ I feel that I am compatible with other students. ○ I can talk to my university/college friends about my family back home. ○ My personal values are in conflict with what is expected at school. ○ The way I speak and/or my physical appearance make it hard for me to fit in with other students. ○ I feel as if I belong on this campus. ○ I can talk to my family back home about my struggles and concerns at school.

Identity Prominence

The identity construct is based on a sociological social psychological perspective of identity theory and is one theoretical lens adopted for this study. The identity prominence scale includes a total of 6 items that were reduced to two independent variables including social identity and professional identity based on the factor analysis described below. Three items measured social identity and 3 items measure professional identity. These items are measured using a 6-point Likert-type scale, (1 = Not at all Important, 2 = Very Unimportant, 3 = Neither Important nor Unimportant, 4 = Very Important, 5 = Extremely Important).

Professional Identity. Professional identity is a three-item scale measuring the perception students have regarding the importance of being identified as a member of their (a) academic community, (b) scientist, (c) and graduate (alum) of their department. The items were measured on a 5-point Likert scale where 1 = Not Important at all and 5 = Extremely Important. Higher levels on the index suggest greater professional identity. The social and Professional identity indices were developed as similar measures used by Carlone and Johnson (2007) and Chemers et al. (2011). The items were further informed by the work and recommendations of Phinney (1992) and Stryker and Serpe (1994).

Social Identity. Social identity is a three-item scale measuring perception of the importance of being identified as a member of the (a) community where respondents grew up, (b) the family they grew up, and (c) someone who shares knowledge with their community. The items were measured on a 5-point Likert scale where 1 = Not Important

at all and 5 = Extremely Important. Higher levels on the index suggest greater social and family identity. The empirical research on underrepresented student experience in STEM and identity theory informed the design of an Identity Prominence Index (Carlone & Johnson, 2007; Chemers et al., 2011; Phinney, 1992; Stryker & Serpe, 1994). Table 3.10 presents the identity prominence items and levels of measurement.

Table 3.10. Identity prominence: A list of the study variables and their levels of measurement.

Explanatory Variables	Coding	Level of Measurement	Item Description
Social Identity Prominence (2 items)	1 = Not at all Important 2 = Very Unimportant 3 = Neither Important nor Unimportant 4 = Very Important 5 = Extremely Important	Interval, 5-point Likert scale	- Being identified as a member of the community where I grew up. - Being identified as a member of the family I grew up with.
Professional Identity Prominence (4 items)	1 = Not at all Important 2 = Very Unimportant 3 = Neither Important nor Unimportant 4 = Very Important 5 = Extremely Important	Interval, 5-point Likert scale	- Being identified as scientist. - Being identified as a graduate of the University that I currently attend. - Being identified as a member of the academic department I am seeking a degree in. - Being identified as someone who shares their knowledge with their community.

Data Analysis

Data Preparation and Preliminary Analyses

Before analysis began the dataset was cleaned and examined for missing values using listwise deletion. For cases that were missing 25% or more of values and systematic omission to responses were systematically removed from the data set and excluded from the analysis. Then each variable was reviewed to ensure that no more than 5% of values were missing, all variables met the criteria. Mean replacement was used for any missing values that remained. Only those students with data on all study variables were included in the final analyses. I calculated descriptive statistics, including frequencies and percentages for the categorical variables to understand the state of the variables (Creswell, 2009). The mean and standard deviations on foci variables are presented in more detail in Chapter Four, see Table 4.1. Given the potential small sample size clustered in each institution (McNeish & Wentzel, 2016) the 12 institutions were collapsed into two categories based on the 2015 Carnegie Classification of Institutions[®]. These include highest research universities (R1) and higher research universities (R2). Institutional type serves as a measure of institutional culture conveyed through size and research intensity signified by the allocation of an R1 versus R2 status.

Factor Analysis

As discussed earlier, I performed a series of exploratory factor analysis to ensure the one-dimensionality of each scale intended to measure the variables under study. The eight items of the intercultural relevancy in STEM scale originally come from the

intercultural framework (Museus & Quaye, 2009). The first exploratory factor analysis I conducted was with the eight items of the Intercultural Relevancy in STEM index. For the Intercultural Relevancy in STEM index, I used principal component extraction, orthogonal varimax rotation which produced two factors with eigenvalues greater than 1.0. The factors were rotated using orthogonal varimax rotation. The first factor accounted for 39% of the variance, the second factor accounted for 22% of the variance. Table 3.11 shows the items and factor loadings for the rotated factors, even loadings .40 and below are included to ensure clarity of the factors.

The first factor appeared to group three items that represent a construct from the intercultural framework, “Cultural Integrity in STEM”. The first three items had the highest loadings and none of the loadings were negative. The second factor represents three items derived from proposition three of the intercultural framework, “Connections with Cultural Representatives” items. These loaded strongly on the next three items in Table 3.11.

A second factor analysis was performed using orthogonal varimax rotation on the Mentor Interaction scale (10 items). The 10 items of the Mentor Interaction scale loaded strongly on two factors of the scale in this study, a Cronbach’s alpha was calculated based on the sample of international graduate students, see Table 3.12. A third factor analysis was performed using orthogonal varimax rotation on the Identity Prominence scale the first two items had the highest loadings and none of the loadings were negative. The second factor represents four items that reflect professional items. These loaded strongly on the next four items in Table 3.13.

Table 3.11. Factor Analysis Intercultural Relevancy in STEM Scale ($\alpha = .76$)

Please indicate to what extent you agree or disagree with the following statements about your major professor/committee chair.

Item	Factor Loading	
	1	2
Factor 1: Cultural Integrity in STEM (3 items, $\alpha = .89$)		
My experiences in STEM are shaped by my cultural meaning systems.	0.89	0.10
I have a strong cultural identity that guides the meanings that I attach to my interest in STEM.	0.93	0.07
It is important for me to see how my culture of origin aligns with the STEM environment.	0.86	0.13
I experience very few cultural conflicts with my STEM education. (Excluded from analysis due to low factor loading)	0.26	0.24
Factor 2: Connections with Cultural Representatives (3 items, $\alpha = .83$)		
Graduate students who experience cultural conflict must adjust to the dominant culture on the campus or have good connections at their university with cultural representatives to be persistent. (Excluded from analysis due to low factor loading)	0.12	0.45
The extent that individuals appreciate a graduate student's culture of origin can reduce the amount of cultural conflict experienced by the student, which can increase the student's persistence.	0.02	0.84
The quality and quantity of a graduate student's connections with various cultural representatives on their own campuses is positively associated with their likelihood of persistence.	0.17	0.85
Graduate students are more likely to persist if cultural representatives emphasize educational achievement, educational attainment, value, and cultural heritage.	0.15	0.82
Eigenvalues	3.14	1.78
% of Variance	39%	22%

Table 3.12. Factor Analysis Mentor Interactions Scale ($\alpha = .93$)

Please indicate to what extent you agree or disagree with the following statements about your major professor/committee chair.		
Item	Factor Loading	
	1	2
Factor 1: Mentor's Academic Support ($\alpha = .92$)		
Is regularly available for advising.	0.81	0.30
Meets with me to discuss research	0.84	0.31
Is interested in my goals and projects.	0.79	0.42
Provides constructive criticism on my project/research.	0.83	0.28
Returns my work in a timely manner.	0.82	0.20
Factor 2: Mentor's Cultural Support ($\alpha = .90$)		
Is interested (engaged) in my culture.	0.24	0.82
Is interested in me beyond my academic role (what I can contribute academically.)	0.27	0.82
Is tolerant about any cultural differences between us.	0.38	0.71
Appreciates cultural diversity.	0.37	0.77
Is friendly towards my family.	0.32	0.76
Eigenvalues	6.11	1.23
% of Variance	61%	12%

Table 3.13. Factor Analysis Identity Prominence Scale ($\alpha = .79$)

Please indicate to what extent you agree or disagree with the following statements about your major professor/committee chair.

Item	Factor Loading	
	1	2
Factor 1: Professional Identity ($\alpha = .80$)		
Being identified as scientist.	0.78	0.00
Being identified as a graduate of the University that I currently attend.	0.74	0.33
Being identified as someone who shares their knowledge with their community.	0.78	0.21
Being identified as a member of the academic department I am seeking a degree in.	0.79	0.24
Factor 2 Social Identity ($\alpha = .76$)		
Being identified as a member of the community where I grew up.	0.21	0.86
Being identified as a member of the family I grew up with.	0.11	0.89
Eigenvalues	3.04	1.14
% of Variance	51%	19%

The two other scales that were used from the Graduate Student Experiences survey of the PNW-COSMOS SSRG were the Cultural Congruity scale and the Peer Group Interactions scale. These two scales had been previously validated in other empirical studies, although with undergraduate populations (Gloria & Robinson-Kurpius, 1996; Pascarella & Terenzini, 1980). Table 3.14 compares the Cronbach's alphas of the international graduate student sub-sample and the original graduate student sampling frame from the PNW-COSMOS survey, see Appendix C (Acock, 2018). The Cultural Congruity scale was piloted on undergraduate students of color and validated with Chicano/a undergraduates ($n = 454$), the original Cronbach's alphas ranged from .81 to .89. The Peer Group Interactions scale (Pascarella & Terenzini, 1980) reported alpha reliabilities between .71 to .84.

Table 3.14. PNW-COSMOS Graduate Student Experiences Survey sample comparison of internal reliability coefficients (Cronbach's alphas).

PNW-COSMOS Instrument Scales	Graduate Student Sample, $N = 4,012$	Study Scales (38 items)	IG Student Sample, $n = 953$
Intercultural Relevancy in STEM Scale (7 items, one item removed)	$\alpha = .77$ (Hollist et. al, 2017)	Cultural Integrity in STEM (3 items)	$\alpha = .89$
		Connections with Cultural Representatives (3 items)	$\alpha = .83$
Mentor Interactions (10 items)	$\alpha = .92$ (Hollist et. al, 2017)	Mentor's Academic Support (5 items)	$\alpha = .92$
		Mentor's Cultural Support (5 items)	$\alpha = .90$
Peer Interactions Scale (7 items)	$\alpha = .87$ (Hollist et. al, 2017)	Peer Interaction (7 items)	$\alpha = .85$
Cultural Congruity Scale (9 items)	$\alpha = .81$ (Hollist et. al, 2017)	Cultural Congruity (9 items)	$\alpha = .76$
Identity Prominence Scale (6 items)	$\alpha = .76$ (Hollist et. al, 2017)	Social Identity (2 items)	$\alpha = .76$
		Professional Identity (4 items)	$\alpha = .80$

Note: Reported alphas were based on the project sample $N = 4,012$ (all graduate students) and study sample $n = .953$. Hollist et al. (2017) did not report alphas for specific groups i.e., international graduate students. Scale reliabilities for the current study are based on having complete data from participants.

Analytic Plan: Ordinary Least Squares Regression

The overarching goal of this inquiry is to determine the extent that relationships with faculty mentor and peers, cultural fit, and identity influence intercultural relevancy in STEM for international graduate students at American public research universities.

The data analysis used to address the research questions is described next.

First, the relationships between social interactions and intercultural relevancy in STEM (cultural integrity in STEM for international graduate students are explored through multivariate analyses. To address my research questions, I used block regression in which I entered blocks of variables sequentially to the regression model. I estimated two series of ordinary least squares regression (OLS) models of the focal variables (mentor's academic support, mentor's cultural support, and peer interactions) on each of the two outcome variables from the Intercultural Relevancy in STEM Index — cultural integrity in STEM and connections with cultural representatives while controlling for individual characteristics. These variables include demographic characteristics (gender, race/ethnicity), background characteristics (year in program, advisor guidance, STEM discipline, degree program, and institutional characteristic (institutional type)). The models were organized hierarchically starting with the primary demographics--gender and race—to evaluate the net effect of these attributes on the dependent variables. The second model added the focal independent variable to the original model to assess the main effect of the focal variable on the dependent variable. The final model added a strong set of individual controls and institution control to try and reduce any confounding effects among the relationships. The OLS model building occurs in the following order:

Series 1: Cultural Integrity in STEM

The modeling building order is presented below.

Model 1: Cultural Integrity in STEM = Gender + Race/Ethnicity

Model 2: Cultural Integrity in STEM = Model 1 + Mentor's Academic Support +
Mentor's Cultural Support

Model 3: Cultural Integrity in STEM = Model 2 + Controls (Year in Program, Advisor
Guidance, STEM Discipline, Degree, and Institutional Type)

Model 1: Cultural Integrity in STEM = Gender + Race/Ethnicity

Model 2: Cultural Integrity in STEM = Model 1 + Peer Interactions

Model 3: Cultural Integrity in STEM = Model 2 + Controls (Year in Program, Advisor
Guidance, STEM Discipline, Degree, and Institutional Type)

Full Model: Cultural Integrity in STEM = Mentor's Academic Support + Mentor's
Cultural Support + Peer Interactions + Gender + Race/Ethnicity + Controls (Year in
Program, Advisor Guidance, STEM Discipline, Degree, and Institutional Type)

Model 1: Cultural Integrity in STEM = Gender + Race/Ethnicity

Model 2: Cultural Integrity in STEM = Model 1 + Cultural Congruity Index

Model 3: Cultural Integrity in STEM = Model 2 + Controls (Year in Program, Advisor
Guidance, STEM Discipline, Degree, and Institutional Type)

Model 1: Cultural Integrity in STEM = Gender + Race/Ethnicity

Model 2: Cultural Integrity in STEM = Model 1 + Social Identity + Professional

Identity
Model 3: Cultural Integrity in STEM = Model 2 + Controls (Year in Program, Advisor Guidance, STEM Discipline, Degree, and Institutional Type)

Series 2: Connections with Cultural Representatives

The modeling building order is presented below.

Model 1: Connections with Cultural Representatives = Gender + Race/Ethnicity

Model 2: Connections with Cultural Representatives = Model 1 + Mentor's Academic Support + Mentor's Cultural Support

Model 3: Connections with Cultural Representatives = Model 2 + Controls (Year in Program, Advisor Guidance, STEM Discipline, Degree, and Institutional Type)

Model 1: Connections with Cultural Representatives = Gender + Race/Ethnicity

Model 2: Connections with Cultural Representatives = Model 1 + Peer Interactions

Model 3: Connections with Cultural Representatives = Model 2 + Controls

Full Model: Connections with Cultural Representatives = Mentor's Academic Support + Mentor's Cultural Support + Peer Interactions + Gender + Race/Ethnicity + Controls (Year in Program, Advisor Guidance, STEM Discipline, Degree, and Institutional Type)

Model 1: Connections with Cultural Representatives = Gender + Race/Ethnicity

Model 2: Connections with Cultural Representatives = Model 1 + Cultural Congruity Index

Model 3: Connections with Cultural Representatives = Model 2 + Controls (Year in Program, Advisor Guidance, STEM Discipline, Degree, and Institutional Type)

Model 1: Connections with Cultural Representatives = Gender + Race/Ethnicity

Model 2: Connections with Cultural Representatives = Model 1 + Social Identity + Professional Identity

Model 3: Connections with Cultural Representatives = Model 2 + Controls (Year in Program, Advisor Guidance, STEM Discipline, Degree, and Institutional Type)

Assumptions of Ordinary Least Squares Regression

Before analysis and after, regression diagnostics were performed after each ordinary least squares regression (OLS) estimation to verify that the assumptions of OLS were met. The four essential assumptions that need to be met can be categorized as appropriate specifications for the models. These include relevant variables, linearity, multicollinearity, residuals, homoscedasticity, and independent observations (Mehmetoglu & Jakobsen, 2016). The first assumption of OLS is that a linear relationship exists between the outcome variable and the explanatory variables. OLS regression assumes multivariate normality, and the residuals are normally distributed. Another assumption is that multicollinearity is not present and that the explanatory variables are not highly correlated with each other. The last assumption is the presence of homoscedasticity, which indicates similar variance of terms across the values of the explanatory variables. Heteroskedasticity is a violation of homoscedasticity and indicates the size of the error term differs across values of an explanatory variable (Mehmetoglu & Jakobsen, 2016). I describe the breaches to these assumptions for each study question and how these breaches influenced the analyses below. There was a similar logic built and applied for each set of analyses planned. After I ran diagnostic tests to ensure the

assumptions of OLS were met. Linearity and normality were also checked and correlated at a moderate level. Heteroskedasticity was found. During the data analyses phase several violations were observed. Primarily, heteroskedasticity was present in the analysis with outcome variable one, Cultural integrity in STEM. This effected the analysis for the first three research questions. To address this problem, I ran another series of analyses using robust regression, an alternative method to OLS that can be used when the assumptions are not met to detect influential observations. Zero-order correlations revealed the absence of multicollinearity in the regression analysis, see Appendix E. The skewness and kurtosis statistics evaluated the normality of the outcome variables cultural integrity in STEM and connections with cultural representatives.

Validity of Design

External

External threats to the validity of this study include several possibilities the response rate, survey type, and characteristics of respondents. Participating institutions involved will have better understanding of student perceptions of socialization at their institutions, certainly not the causes of intercultural socialization which could help with future program planning. The sample characteristics also lack an essential feature of international studies, the respondents' nation of origin. Because of this absence of data, the sample cannot be organized by global regions, i.e., Sub-Saharan Africa, Middle East and North Africa, Latin America, Asia, Anglosphere, and Europe. Organization of data by global region is a standard approach in the research on international populations

(Mendoza-Denton et al., 2017). It could be said that this study's findings are generalizable to other international graduate student populations in the United States. The survey did not use a random sampling method, which would have increased our ability to test for causality. The census sample was the preferred method because our recruitment methods of survey participation targeted specific institutions known for their culturally responsive Native American support programs. This intentionality as well as cost and time made census sampling a good choice. The extent to which the data and findings can be generalized to STEM international graduate students in American Higher Education is limited based on a nonrandomized sampling procedure. Therefore, the findings should be interpreted by institutional stakeholders based on how well the data represent a given population of STEM international graduate students at their respective institutions.

Internal

The survey instrument design is the main threat to the internal validity of the study. The internal validity of the study is how well the variables measure the constructs of interest. As noted above, the cross-sectional survey design is a threat to causality based on the inability to assess a time-order between the independent and dependent variables. Cross-sectional design is not considered a threat to generalizability; however, this design is a threat to assuming causality. The instrument, the PNW-COSMOS Graduate Student Experiences survey, includes 9 scales and draws from several areas to investigate cultural congruity and environmental fit during the socialization of diverse groups in graduate education. The cultural congruity and peer interaction scales were previously validated in a number of empirical studies on White/Caucasian, African American, American

Indian/Alaska Native, and Hispanic (Latinx and Chicano/a) undergraduate students who attended predominately white institutions and community colleges (Gloria et al., 2016; Gloria, Robinson-Kurpius, Hamilton, & Willson, 1999; Gloria & Robinson-Kurpius, 1996; Pascarella & Terenzini, 1980). Three other scales in this study were adapted from the literature on graduate students that intend to measure intercultural relevancy in STEM, mentor interaction, and peer interaction (Barnes & Austin, 2009b; Gardner & Barnes, 2007; Huffman, 2001; Kuh & Love, 2000; Museus & Quaye, 2009; Prime et al., 2014). The last scale measures professional and social identity prominence (Brenner et al., 2014; Stets, Brenner, Burke, & Serpe, 2017; Stets & Burke, 2000; Stryker, 1968). The PNW-COSMOS research group were responsible for development of the instrument.

The principle limitation of the study is evaluating each scales ability to measure the constructs it was built to measure. For an international sample the survey process has linguistic limitations. Misinterpretation of the key concepts of the instrument is possible due to linguistic and cultural differences. To address this limitation, definitions were provided in the survey such as, persistence, cultural conflict, and cultural representatives. To address other threats to the internal validity I explain the extent that this study's results relate to cultural congruity, social interactions, and identity and identify alternative explanations for my findings. Another threat to internal validity is the way citizenship is treated as a binary variable: international (temporary resident) or U.S. citizen status. Multi-dimensional notions of citizenship, dual citizenship, and border crossings reflect the dynamic geopolitics of student mobility and obsolete notion of "brain drain". Students may traverse multiple cultural contexts by the time they enter

graduate school in the U.S. (Marginson, 2018; Marginson & Rhoades, 2002; Phelps, 2016). Although secondary data can also contribute to our understandings of socialization and other explanations for the strength of the relationships between the variables: social interaction, cultural congruity, identity, and intercultural relevancy. The nested structure of the data violates the independence assumption of OLS regression, because the clusters of observations are not independent of each other. Hierarchical Linear Modeling was not used in the analysis because there would need to be a larger sample size for adequate power (Woltman, Feldstain, MacKay, & Rocchi, 2012). Students' timing in the U.S. and experiences with travel could also threaten the internal validity and could be a confounding variable, as we live in a globalized world where communications are instant and travel more accessible.

Chapter Three Summary: Methodology

Chapter Three outlined the research design and the methodological approach used to examine the association international graduate students' socialization experiences (social interactions, levels of cultural congruity, and identity prominence) and the extent that these factors influence intercultural relevancy in STEM (cultural integrity in STEM and connections with cultural representatives — at American public research universities. Secondary data analysis was conducted on survey data from the PNW-COSMOS Graduate Student Experiences survey, a 37-item instrument analysis was conducted using multivariate statistics. This quantitative study sample drew from the sampling frame of all graduate student who responded to the survey. Of the 4,012 graduate students who

received the survey 1,085 were from international graduate students, for a 17% overall response rate. Data analysis found the instrument measures reliable in determining the association among intercultural relevancy in STEM and factors of socialization. The external validity of the study is adequate though there are some limitations that may affect the internal validity of the study. The results of the study provide information that builds on the existing research on the socialization experiences of STEM international graduate students at American public research universities. This empirical study is unique in that it investigates STEM international graduate students' perceptions of the graduate experience in the United States and the extent to which socialization factors are related to intercultural relevancy in STEM (cultural integrity in STEM and connections with cultural representatives).

The methodological approach and analytic order of this study is theory driven. OLS models the relationship of each outcome variable on several explanatory variables. The results presented in the next chapter provide the estimations of the strength and directionality between the explanatory variables and intercultural relevancy in STEM controlling for individual and institutional characteristics of international graduate students. The latent construct of intercultural relevancy in STEM is operationalized by cultural integrity in STEM and connections with cultural representatives. The degree to which the importance of cultural integrity in STEM and connections with cultural representatives as a function of socialization (mentor's academic and social support, peer interactions), levels of cultural congruity, and social and professional identity prominence of international graduate students is assessed and explained in Chapter Four.

CHAPTER FOUR RESULTS

Introduction

In Chapter Four I explain the results from this study that examined STEM international graduate students' mentor and peer relationships, cultural fit, and identity influence intercultural relevancy as parts of the socialization process at American public research universities. The intent of this multiple regression analyses was to determine the strength and direction among the study variables. The analysis also examines the contributions of demographic and background characteristics to provide insights about international graduate students' socialization in STEM.

In the next section, I present descriptive statistics to show the general characteristics of the international graduate student sample ($n = 953$) who participated in the Graduate Student Experiences survey (GSE) and the foci variables under study. These variables include two outcome variables that operationalize intercultural relevancy in STEM. These are cultural integrity in STEM and connections with cultural representatives. The six explanatory variables are mentor's cultural support, mentor's academic support, peer interaction, cultural congruity, professional identity, and social identity.

Descriptive Statistics of Study Sample and Foci Variables

Beginning with a sampling frame of 1,085 self-reported international graduate students, I prepared data by removing missing variables accordingly. I delimited the

sample to international graduate students ($n = 953$) who had complete data on all the study variables for a final analytical sample (Downey & King, 1998). I used Stata IC/15 to conduct all analytical procedures.

The means and standard deviations of the study variables are displayed Table 4.1. The outcome variable, cultural integrity in STEM, is a composite index of three validated items from the intercultural relevancy in STEM scale, Table 3.7 is in Chapter Three. These items are measured on a Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). International graduate students' mean index scores show mid to high levels of cultural integrity in STEM ($M = 3.44$, $SD = .89$). The second outcome variable, connections with cultural representatives, is also a composite index of three validated items from the Intercultural Relevancy in STEM scale. It measures students' perceptions about the value of cultural representatives in the graduate education milieu. Scores are marginally higher on outcomes variable two, indicated by mid to high levels of connections with cultural representatives ($M = 3.74$, $SD = .65$). The Social Interaction indices includes three scales that were each measured on a Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Ten items in total indicate mentor interaction, five for the mentor's cultural support scale and five items for the mentor's academic support scale. Seven items represent the Peer Interaction scale. Like the outcome variables, the social interaction variables also indicate mid to high levels of mentor's cultural support, ($M = 3.87$, $SD = 0.76$), mentor's academic support ($M = 4.17$, $SD = 0.77$), and peer interactions ($M = 3.67$, $SD = 0.72$). The nine items that represent Cultural Congruity index were measured on a different Likert scale (1 = Not at all True to 7=Very True).

International graduate students scores indicate high levels of cultural congruity ($M = 5.13$, $SD = 1.01$). The identity scale items are also measured on a Likert scale (1 = Not at All Important to 5 = Very Important). International graduate students' STEM international graduate students' rate professional identity ($M = 4.07$, $SD = 0.68$) at a higher level of importance than social identity ($M = 3.78$, $SD = 0.94$).

Table 4.1. Means and Standard Deviations of Study Variables (n = 953)

Study Variables and Items	Range	Sample M (SD)
Outcome Variables		
Cultural Integrity in STEM	1-5	3.44 (.89)
My experiences in STEM are shaped by my cultural meaning systems.		3.48 (.96)
I have a strong cultural identity that guides the meanings that I attach to my interest in STEM.		3.43 (.98)
It is important for me to see how my culture of origin aligns with the STEM environment.		3.39 (1.00)
Connections with Cultural Representatives	1-5	3.74 (.65)
The extent that individuals appreciate a graduate student's culture of origin can reduce the amount of cultural conflict experienced by the student, which can increase the student's persistence.		3.82 (.77)
The quality and quantity of a graduate student's connections with various cultural representatives on their own campuses is positively associated with their likelihood of persistence.		3.73 (.75)
Graduate students are more likely to persist if cultural representatives emphasize educational achievement, educational attainment, value, and cultural heritage.		3.68 (.76)

Table 4.1 continued

Study Variables and Items	Range	Sample M (SD)
Explanatory Variables		
Mentor's Academic Support	1-5	4.17 (.77)
Is regularly available for advising.		4.18 (.88)
Meets with me to discuss research		4.24 (.86)
Is interested in my goals and projects.		4.20 (.88)
Provides constructive criticism on my project/research.		4.20 (.88)
Returns my work in a timely manner.		4.05 (.93)
Mentor's Cultural Support	1-5	3.87 (.76)
Is interested (engaged) in my culture.		3.65 (.93)
Is interested in me beyond my academic role (what I can contribute academically.)		3.67 (1.01)
Is tolerant about any cultural differences between us.		4.09 (.86)
Appreciates cultural diversity.		4.07 (.83)
Is friendly towards my family.		3.87 (.88)
Peer Interactions Composite Index	1-5	3.67 (.72)
Since coming to this university, I have developed close personal relationships with other students.		3.73 (.98)
The student friendships I have developed at this university have been personally satisfying.		3.79 (.90)
My interpersonal relationships with other students have had a positive influence on my intellectual growth and interests in ideas.		3.88 (.89)
It has been difficult for me to meet and make friends with other students		3.88 (.90)
Students would be willing to listen to me and help if I had personal problems.		3.48 (1.20)
My interpersonal relationships with other students have had a positive influence on my personal growth, attitudes, and values.		3.66 (.94)
I am more likely to attend a cultural event (for example, a concert, lecture, or art show) now than I was before coming to this university.		3.26 (1.13)

Table 4.1 continued

Study Variables and Items	Range	Sample M (SD)
Explanatory Variables		
Cultural Congruity Composite Index	1-7	5.13 (1.01)
I feel that I have to change myself to fit in.		4.19 (1.98)
I try not to show the people around me who I really am.		5.30 (1.82)
I often feel like a chameleon, having to change who I am depending on the person I am with.		5.23 (1.79)
I feel that I am compatible with other students.		5.20 (1.45)
I can talk to my university/college friends about my family back home.		5.26 (1.61)
My personal values are in conflict with what is expected at school.		5.83 (1.50)
The way I speak and/or my physical appearance make it hard for me to fit in with other students.		4.80 (1.65)
I feel as if I belong on this campus.		4.80 (1.45)
I can talk to my family back home about my struggles and concerns at school		4.94 (1.86)
Social Identity Composite Index	1-5	4.07 (.68)
Being identified as a member of the community where I grew up.		3.58 (1.06)
Being identified as a member of the family I grew up with.		3.98 (1.04)
Professional Identity Composite Index	1-5	3.78 (.94)
Being identified as scientist.		3.98 (.90)
Being identified as a graduate of the University that I currently attend.		3.97 (.89)
Being identified as someone who shares their knowledge with their community.		4.24 (.76)
Being identified as a member of the academic department I am seeking a degree in.		4.11 (.83)

In the next section, statistical analyses of the study data used to investigate the research questions were completed using ordinary least squares regression (OLS) model building approach. I entered blocks of variables sequentially to the regression model and then examined possible associations between the outcome variable — cultural integrity in STEM and connections with cultural representatives — on the explanatory variables —

mentor's cultural support, mentor's academic support, peer interactions, cultural congruity, social and professional identity prominence — while holding controls constant. Further, I ran interactions and determined there were no significant findings. In the next section I present an overview of the results and detailed findings from both sets of regression models. Each model estimation is aligned with its' corresponding research question.

Results Overview

The goal of this research was to explore the socialization experiences of international graduate students. The specific research questions are:

Research Questions: Cultural Integrity in STEM

1. To what extent do STEM international graduate students' social interactions with their faculty mentors and peers influence their cultural integrity in STEM at American public research universities?
2. To what extent do STEM international graduate students' levels cultural congruity influence their cultural integrity in STEM at American public research universities?
3. To what extent do STEM international graduate students' social and professional identity prominence influence their cultural integrity in STEM at American public research universities?

Research Questions: Connections with Cultural Representatives

4. To what extent do STEM international graduate students' social interactions with their faculty mentors and peers influence their connections with cultural representatives at American public research universities?
5. To what extent do STEM international graduate students' levels cultural congruity influence their connections with cultural representatives at American public research universities?
6. To what extent do STEM international graduate students' social and professional identity influence their connections with cultural representatives at American public research universities?

To evaluate my research questions, I estimated a series of OLS models where cultural integrity in STEM and connections with cultural representatives were the outcome variables. Intercultural relevancy in STEM is the latent construct for two distinct constructs, cultural integrity in STEM and connections with cultural representatives. The three other constructs of the socialization process examined independently of each other include social interactions, cultural congruity, and identity prominence. Social interaction, a latent construct, is indicated by three explanatory variables: mentor's cultural support, mentor's academic support, and peer interactions. The mentor items chosen for the GSE survey instrument were taken from validated scales that intend to measure mentoring behaviors of graduate research supervisors/advisors (Barnes, Chard, Wolfe, Stassen, & Williams, 2011; Prime et al., 2014; Schlosser & Gelso, 2001). The next explanatory variable examines cultural fit, which is measured by the Cultural

Congruity scale. Identity prominence is the latent construct of social identity prominence and professional identity prominence in this study. The Identity index was also developed for the GSE survey instrument.

OLS assesses the strength and direction of an outcome variable by modeling the relationship of explanatory variables. In successive order, I regress the outcome variable (cultural integrity in STEM and connections with cultural representatives) on five explanatory variables while controlling for individual and background variables. The regression model building approach which occurs in the following order for each robust model estimation: first assessed are the demographic characteristics (gender and race/ethnicity), then the explanatory variable(s) are added (i.e., mentor's academic support and mentor's cultural support), and in the final model all other background variables. These background variables serve as controls and include the year in program, advisor guidance, STEM discipline, degree, and the institutional type.

I begin by adding demographic characteristics first to account for people's enduring characteristics such as gender and race. Model 1 served two purposes. First, the model tests the net effect of gender and race on the levels of cultural integrity in STEM. Second, Model 1 assess the within-group differences among the sample of international graduate students. In Model 2 I regress the outcome variable on each explanatory variable(s) that is added to the model. In the final model, Model 3, the controls (background and institutional characteristics) are added to complete the multiple regression estimations. This same modeling approach is repeated for the 6 research questions.

Each set of models illustrate three main statistics. First, the R-square is specified, indicating the percent of variance explained by the linear combination of explanatory variables. The R-square measure assesses the relevancy and usefulness of the additional variables added to the models. Next, I examine the model specification using the F-test to determine the linear combination of variables and statistical significance of each model. Last, I review the unstandardized coefficients standard error, and *p*-values to understand the direction and strength of the relationships between the explanatory variables on the outcome variable when holding all other controlling variables in the model constant.

Model Series 1: OLS Regression Models for the Dependent Variable: Cultural Integrity in STEM

Research Question 1: Relationship between Social Interactions and Cultural Integrity in STEM

The aim of research question one was to understand the relationships between international graduate students' social interactions and perceived levels of cultural integrity. The following models were used to test these relationships:

Model 1: $Y = \text{Gender} + \text{Race/Ethnicity}$

Model 2: $Y = \text{Model 1} + \text{Focal Variables}$

Model 3: $Y = \text{Model 2} + \text{strong set of Controls}$

Table 4.2 shows the regression results for cultural integrity in STEM on the demographic variables gender and race and ethnicity. In this first model, The F-test for Model 1 was

found statistically significant. There was a significant effect of gender and race/ethnicity on cultural integrity in STEM ($R^2 = .01$, $F_{6, 946} = 2.37$, $p < .05$) which could indicate that this combination of explanatory variables does contribute somewhat to the overall model fit when compared to the restricted model. Mentor's academic and cultural support were added in Model 2. The F-test for Model 2 increased in statistical significance ($R^2 = .07$, $F_{8, 944} = 8.59$, $p < .01$) and remained significant in Model 3, ($R^2 = .08$, $F_{15, 937} = 6.26$, $p < .01$). In Model 1, the unstandardized coefficients for White/Caucasian international graduate students ($b = -.374^{***}$, $se = .13$, $p < .05$) show lower levels of cultural integrity in STEM compared to Asian/Pacific Islander students, which is the reference group for race analysis. Hispanic/Latino/a students ($b = -0.207^*$, $se = 0.11$, $p < .05$) also have lower levels of cultural integrity in STEM compared to Asian/Pacific Islander students. This finding in racial differences persisted in Model 2 and Model 3. Next, mentor's academic and cultural support is added in Model 2. Mentors' cultural support was the only significant predictor of levels of cultural integrity in STEM. Levels of cultural integrity in STEM are higher if they also report higher levels of mentors' cultural support ($b = .279^{***}$, $se = .05$, $p < .01$). For every 1 unit change increase in levels of mentors' cultural support there is a .279 increase in levels of cultural integrity in STEM. Last, I test the robustness of these relationships in Model 3 with the addition of background characteristics or controls in the regression equation. Here, the results remain constant for mentors' cultural support as the controls such as advisor guidance and degree program may explain something about the relationships in Model 2 and 3. Mentors' cultural support, ($b = .279^{***}$, $se = .05$, $p < .01$) and students in master's degree ($b = .207^{***}$, $se =$

.07, $p < .01$) are both significantly associated with cultural integrity in STEM. Mentors' academic support is not associated with cultural integrity experiences in STEM. The fit of the model is rather small with an R-square of .08.

Mentors' cultural support is positively associated with international students' cultural integrity experiences in STEM. The international graduate student sample report higher levels of cultural integrity in STEM when they report higher levels on the mentors' cultural support index. The background controls fail to explain differences in cultural integrity in STEM as R-square only increased .01. The full model explained 8% of international graduate students' level of cultural integrity experiences in STEM. Next, another multiple regression was performed to evaluate the relationship between international students' levels of cultural integrity in STEM and peer interactions.

Table 4.2. Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Mentor's Support (n = 953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Mentor's Academic Support		0.009 (0.05)	0.006 (0.05)
Mentor's Cultural Support		0.279*** (0.05)	0.279*** (0.05)
Male (Reference)			
Female	0.067 (0.06)	0.061 (0.06)	0.059 (0.06)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.374*** (0.13)	-0.393*** (0.12)	-0.357*** (0.12)
Arab/Middle Easterner	-0.076 (0.13)	-0.085 (0.14)	-0.038 (0.14)
Black/African	0.118 (0.17)	0.046 (0.16)	0.039 (0.16)
Hispanic/Latino/a	-0.207* (0.11)	-0.264** (0.10)	-0.242** (0.11)
Other	-0.010 (0.12)	-0.062 (0.12)	-0.049 (0.12)
Year			0.005 (0.020)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.123* (0.07)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.065 (0.08)
Applied, Life, Hard			0.065 (0.12)
Applied, Non-Life, Hard			0.033 (0.08)
Doctoral Degree (Reference)			
Master's Degree			0.207*** (0.07)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			-0.090 (0.07)
Constant	3.47*** (0.04)	2.36*** (0.17)	2.35*** (0.21)
Adjusted <i>R</i> ²	0.01	0.07	0.08

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10

Table 4.3 illustrates peer interactions and cultural integrity in STEM. In Model 1, the F-test was found statistically significant ($R^2 = .01$, $F_{6, 946} = 2.37$, $p < .05$). The unstandardized coefficients for White/Caucasian students ($b = -.374^{***}$, $se = .13$, $p < .01$) indicating that white international students have lower levels of cultural integrity compared to Asian/Pacific Islander students. Similarly, Hispanic/Latino/a students have lower cultural integrity compared to Asian/Pacific Islander students ($b = -.207^*$, $se = .11$, $p < .10$) a finding that remains consistent across all three models. Peer interaction is positively associated with international graduate students' cultural integrity in STEM indicating that students who score higher on this variable have higher levels of cultural integrity in STEM. ($b = .266$, $se = .05$, $p < .01$). This indicates that for a one unit increase in positive peer interactions students score over a quarter point higher on the cultural integrity scale. Students who do not seek advisor guidance ($b = -.191^{***}$, $se = .07$, $p < .01$) have lower levels of cultural integrity than students who do seek guidance. Students in master's degree programs guidance ($b = .181^{***}$, $se = .07$, $p < .01$) have higher levels of cultural integrity in STEM compared to those in a doctoral program. The full model explained 7% of international graduate students' cultural integrity in STEM in the model framework below.

Table 4.3. Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Peer Interactions (n =953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Peer Interactions		0.266*** (0.047)	0.254*** (0.046)
Male (Reference)			
Female	0.0671 (0.058)	0.0601 (0.058)	0.0486 (0.059)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.374*** (0.13)	-0.314** (0.12)	-0.292** (0.12)
Arab/Middle Easterner	-0.0762 (0.13)	-0.0227 (0.12)	0.0228 (0.12)
Black/African	0.118 (0.17)	0.0212 (0.16)	0.000319 (0.17)
Hispanic/Latino/a	-0.207* (0.11)	-0.214* (0.11)	-0.208* (0.11)
Other	-0.0100 (0.12)	0.0164 (0.12)	0.0172 (0.12)
Year			0.00644 (0.020)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.191*** (0.066)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.0839 (0.085)
Applied, Life, Hard			0.0782 (0.13)
Applied, Non-Life, Hard			-0.00989 (0.080)
Doctoral Degree (Reference)			
Master's Degree			0.181** (0.071)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			-0.0925 (0.069)
Constant	3.465*** (0.040)	2.486*** (0.18)	2.553*** (0.20)
Adjusted R^2	0.01	0.06	0.07

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Research Question 2: Relationship between Cultural Congruity and Cultural Integrity in STEM

The aim of research question two was to understand the relationships between international graduate students' cultural congruity and perceived levels of cultural integrity. The following models were used to test these relationships:

Model 1: $Y = \text{Gender} + \text{Race/Ethnicity}$

Model 2: $Y = \text{Model 1} + \text{Focal Variables}$

Model 3: $Y = \text{Model 2} + \text{strong set of Controls}$

Robust regression was performed to evaluate the relationship between international students' levels of cultural integrity in STEM on cultural congruity. Table 4.4 shows the results that assess levels of cultural congruity and the extent it predicts levels of cultural integrity in STEM. Using the same modeling approach, I regress cultural integrity on gender and race. The F-test for Model 1 was again found statistically significant ($R^2 = .01$, $F_{6, 946} = 2.37$, $p < .05$). Cultural congruity was then added in Model 2. The F-test for Model 2 is statistically nonsignificant ($R^2 = .01$, $F_{7, 945} = 2.07$, $p < .10$). In Model 3 the R square increases slightly and F-test increases to statistically significant, ($R^2 = .03$, $F_{14, 938} = 2.87$, $p < .01$). In Model 1 and 2 White/Caucasian students have lower levels of cultural integrity in STEM when compared to Asian/Pacific Islander students, the reference group (Table 4.4). This finding in racial differences persisted in Model 3 for White/Caucasian students ($b = -.374^{***}$, $se = 0.13$). Similarly, Hispanic/Latino/a students ($b = -.207^*$, $se = 0.11$) also have lower levels of cultural integrity in STEM compared to

Asian/Pacific Islander students. Model 2 Hispanic/Latino/a students continue to have lower cultural integrity and the unstandardized coefficient continued to be significant across the models ($b = -.214^{**}$, $se = 0.11$), this difference persisted in Model 3 for Hispanic/Latina/o students ($b = -.206^{*}$, $se = 0.11$). In Model 2, I added cultural congruity which was not significantly associated with cultural integrity experiences in STEM; a finding that remained in Model 3. The fit of the model is rather small with an R-square of .04. In Model 3, I test the robustness of these relationships by including the background controls in the regression equation. In Model 3, students who report that they do not seek advisor guidance ($b = -.246^{***}$, $se = 0.07$) have lower levels of cultural integrity in STEM than those who indicate they do seek guidance. In turn, students who are in master's degree programs ($b = .185^{**}$, $se = 0.07$) have higher levels of cultural integrity in STEM than doctoral students. Cultural congruity fails to explain because it is not significant. The full model explained 3% of international graduate students' levels of cultural integrity experiences in STEM.

Table 4.4. Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Cultural Congruity (n =953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Cultural Congruity		0.017 (0.03)	-0.001 (0.03)
Male (Reference)			
Female	0.067 (0.06)	0.066 (0.06)	0.051 (0.06)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.374*** (0.13)	-0.378*** (0.13)	-0.353*** (0.12)
Arab/Middle Easterner	-0.0762 (0.13)	-0.0763 (0.13)	-0.0265 (0.13)
Black/African	0.118 (0.17)	0.116 (0.17)	0.0823 (0.17)
Hispanic Latina/o	-0.207* (0.11)	-0.214** (0.11)	-0.206* (0.11)
Other	-0.0100 (0.12)	-0.0152 (0.12)	-0.0128 (0.12)
Year			0.0106 (0.021)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.246*** (0.068)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.0848 (0.087)
Applied, Life, Hard			0.0819 (0.13)
Applied, Non-Life, Hard			-0.0110 (0.081)
Doctoral Degree (Reference)			
Master's Degree			0.185** (0.073)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			-0.0760 (0.070)
Constant	3.465*** (0.040)	3.377*** (0.16)	3.495*** (0.18)
Adjusted R^2	0.01	0.01	0.03

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Research Question 3: Relationship between Identity Prominence and Cultural Integrity in STEM

The aim of research question three was to understand the relationships between international graduate students' identity and perceived levels of cultural integrity. The following models were used to test these relationships:

Model 1: DV = Gender + Race/Ethnicity

Model 2: Model 1 + Focal variables

Model 3: Model 2 + strong set of controls

Table 4.5 presents findings for the strength and direction of identity prominence on levels of cultural integrity in STEM. The F-test for Model 1 was found statistically significant ($R^2 = .01$, $F_{6, 946} = 2.37$, $p < .05$). The F-test statistical significance increases in Model 2 ($F_{8, 944} = 9.66$, $p < .01$). The significance remains consistent in the third and final model ($F_{15, 937} = 6.73$, $p < .01$). White/Caucasian students ($b = -.374^{***}$, $se = .13$) have lower levels of cultural integrity in STEM when compared to the reference group, Asian/Pacific Islander students, a finding that remains significant through Model 3. Hispanic/Latino/a students have lower cultural integrity when compared to the reference group, Asian/Pacific Islander students, in Model 1, ($b = -.207^*$, $se = 0.11$). This difference is statistically nonsignificant for Hispanic/Latino/a students in Model 2 and 3. In Model 2 both social ($b = .240^{***}$, $se = .04$) and professional identity prominence ($b = .095^*$, $se = .05$) are statistically significant and positively associated with cultural integrity in STEM; a finding that remained in Model 3 from Model 2. Of the background characteristics those students who do not seek advisor guidance ($b = -.207^{***}$, $se = .06$) display lower levels of cultural integrity in STEM compared to students who do seek advisor guidance.

Master's degree students ($b = .179^{**}$, $se = .07$) have higher levels of cultural integrity in STEM compared to doctoral students. Overall in the full model social identity prominence, ($b = .234^{***}$, $se .04$) has a stronger relationship with levels of cultural integrity in STEM than professional identity, ($b = .089^*$, $se .05$). Three models show the results: the first model considers only demographic characteristics, then added to the model are social and professional identity variables, and last all the other background characteristics are added to the final model. Each modification modestly improves the model's explanatory power, from 1% of variance explained in Model 1, to 9% in Model 2, to the highest explained variance of all the study's models, 10%, in the full model.

Table 4.5. Unstandardized OLS Regression Coefficients for International Graduate Students Levels of Cultural Integrity in STEM on Identity Prominence (n =953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Social Identity		0.240*** (0.041)	0.234*** (0.041)
Professional Identity		0.0952* (0.051)	0.0887* (0.051)
Male (Reference)			
Female	0.0671 (0.058)	0.0618 (0.057)	0.0482 (0.058)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.374*** (0.13)	-0.228* (0.12)	-0.217* (0.12)
Arab/Middle Easterner	-0.0762 (0.13)	-0.0750 (0.12)	-0.0261 (0.12)
Black/African	0.118 (0.17)	-0.0550 (0.17)	-0.0730 (0.17)
Hispanic/Latino/a	-0.207* (0.11)	-0.141 (0.10)	-0.143 (0.10)
Other	-0.0100 (0.12)	-0.00205 (0.13)	-0.00312 (0.13)
Year			0.0204 (0.020)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.207*** (0.064)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.0650 (0.084)
Applied, Life, Hard			0.0442 (0.12)
Applied, Non-Life, Hard			-0.0114 (0.078)
Doctoral Degree (Reference)			
Master's Degree			0.179** (0.070)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			-0.0676 (0.067)
Constant	3.47***(.04)	2.16***(.20)	2.19***(.22)
Adjusted <i>R</i> ²	0.01	0.09	0.10

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Model Series 2: OLS Regression Models for the
Dependent Variable: Connections with Cultural Representatives

These next set of models examine if STEM international graduate students' levels of connections with cultural representatives in STEM is a function of social interactions (mentors' academic support, mentors' cultural support, and peer interactions), cultural congruity, and identity prominence. The modeling strategy for this set of models follows the same procedures as with the previous set of models. The goal is to test the unique contributions of each of the independent variables and its relationship to cultural representatives. As with the previous analysis, each series of OLS modeling began by regressing the outcome variable on the demographic characteristics of international graduate students (gender and race/ethnicity) in order to theoretically account for enduring characteristics of the individual. Then Model 2 was used to examine the focal independent variable to assess the primary relationship of interest. The final Model 3 added a strong set of controls to the previous analyses to help explain any additional relationships.

Research Question 4: Relationship between Social Interactions
and Connections with Cultural Representatives

The aim of research question four was to understand the relationships between international graduate students' social interactions and perceived levels of connections with cultural representatives. The following models were used to test these relationships:

Model 1: $Y = \text{Gender} + \text{Race/Ethnicity}$

Model 2: $Y = \text{Model 1} + \text{Focal variables}$

Model 3: $Y = \text{Model 2} + \text{strong set of controls}$

Two sets of models were used to estimate the relationship between international students' social interaction and their perceived connections to cultural representatives. The first set of models examined the extent to which international graduate students' interaction with mentor predicted their perceived levels of connections to cultural representatives. The second set of models examined the extent to which international graduate students' interaction with peers predicted their perceived levels of connections to cultural representatives.

Using the same model building strategy as with the previous independent variable, the first set of models, regressed connections with cultural representatives on race and gender. The F-test for Model 1 is statistically significant ($R^2 = .02$, $F_{6, 946} = 4.92$, $p < .01$) which could indicate that this combination of explanatory variables does contribute somewhat to the overall model fit when compared to the restricted model. Mentor's academic and cultural support were added in Model 2. The F-test for Model 2 increased in statistical significance ($R^2 = .05$, $F_{8, 944} = 6.72$, $p < .01$) and remained significant in Model 3, ($R^2 = .05$, $F_{15, 937} = 4.14$, $p < .01$). Like the first series of analyses, in Model 1 of set two, I regressed connections with cultural representatives on race and gender. White/Caucasian students ($b = -.167^{**}$, $se = .07$) have lower levels of connections with cultural representatives when compared to the reference group, Asian/Pacific Islander students. Alternately, Black/African students ($b = .399^{***}$, $se = .12$). and Hispanic/Latino/a students ($b = .242^{***}$, $se = .08$) have stronger connections with cultural representatives. This pattern of significance holds through the three models.

Next, in Model 2, mentors' cultural support is positively associated with stronger levels of connections with cultural representatives ($b = .113^{***}$, $se .04$). A pattern that holds for Model 3 when the controls are added. Conversely, mentor's academic support is not associated with a students' perceived level of connections with cultural representatives. In the full model with controls, students who attend R2 institutions ($b = .084^*$, $se = .05$, $p < .10$) report higher levels of cultural integrity than students who attend R1 institutions.

Overall, mentors' cultural support is statistically significant, whereas mentor's academic support is not significantly associated with a students' connections with cultural representatives. The full model explained 5% of international graduate students' connections with cultural representatives. Next, I evaluate the relationship between relationship between international students' connections with cultural representatives and peer interactions.

Table 4.6. Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Mentor's Support (n =953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Mentor's Academic Support		0.027 (0.036)	0.002 (0.038)
Mentor's Cultural Support		0.113*** (0.037)	0.111*** (0.037)
Male (Reference)			
Female	0.0455 (0.043)	0.0423 (0.043)	0.0332 (0.044)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.167** (0.073)	-0.177** (0.072)	-0.195*** (0.073)
Arab/Middle Easterner	-0.00729 (0.086)	-0.0104 (0.085)	-0.0259 (0.086)
Black/African	0.399*** (0.12)	0.365*** (0.12)	0.344*** (0.12)
Hispanic/Latino/a	0.242*** (0.077)	0.217*** (0.076)	0.192** (0.078)
Other	0.00442 (0.088)	-0.0206 (0.087)	-0.0299 (0.087)
Year			0.00441 (0.015)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.0849 (0.054)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.0714 (0.065)
Applied, Life, Hard			-0.0451 (0.11)
Applied, Non-Life, Hard			-0.0247 (0.059)
Doctoral Degree (Reference)			
Master's Degree			-0.0475 (0.054)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			0.084* (0.05)
Constant	3.71*** (0.03)	3.17*** (0.12)	3.32*** (0.16)
Adjusted <i>R</i> ²	0.02	0.05	0.05

Note: Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The second set of models estimated the international students' connections with cultural representatives as a function of social interactions with peers. The F-test for Model 1 is statistically significant ($R^2 = .02$, $F_{6, 946} = 4.92$, $p < .01$), which could also indicate that race and gender do contribute somewhat to the overall model fit when compared to the restricted model. Peer interactions were added in Model 2. The F-test for Model 2 ($R^2 = .05$, $F_{8, 944} = 7.88$, $p < .01$) and remained significant in Model 3, ($R^2 = .05$, $F_{15, 937} = 4.14$, $p < .01$).

Concerning peer interactions, when I regressed connections with cultural representatives on race and gender. White/Caucasian students ($b = -.167^{***}$, $se = .07$) continue to score lower on connections with cultural representatives when compared to the reference group, Asian/Pacific Islander students, this pattern holds for the full model. Black/African students ($b = .399^{***}$, $se = .12$) and Hispanic/Latino/a students ($b = .242^{***}$, $se = .07$) students report stronger connections to cultural representatives than Asian Pacific Islander students, and this pattern remains into the full model. Peer interaction is positively associated with international graduate students' who report stronger connections with cultural representatives, indicating that students who have stronger interaction with peers also tend to value cultural connections with people. In the full model when the strong set of controls are added, of the background characteristics only those students who do not seek advisor guidance are less likely to have connections with cultural representatives than students who do seek guidance from their advisor ($b = -.105^{**}$, $se = .05$). The full model explained 5% of international graduate students' connections with cultural representatives.

Overall, both mentors' cultural support and peer interactions positively influence connections with cultural representatives. These results indicate that after accounting for individual and background characteristics, those students who have positive mentors' cultural support and peer interaction also place greater value on connections with cultural representatives.

Table 4.7. Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Peer Interactions (n = 953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Peer Interactions		0.144*** (0.029)	0.132*** (0.029)
Male (Reference)			
Female	0.0455 (0.043)	0.0417 (0.043)	0.0289 (0.044)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.167** (0.073)	-0.135* (0.073)	-0.162** (0.073)
Arab/Middle Easterner	-0.00729 (0.086)	0.0216 (0.085)	0.00425 (0.086)
Black/African	0.399*** (0.12)	0.346*** (0.12)	0.318*** (0.12)
Hispanic/Latino/a	0.242*** (0.077)	0.238*** (0.076)	0.206*** (0.077)
Other	0.00442 (0.088)	0.0187 (0.086)	0.000145 (0.087)
Year			0.00452 (0.015)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.105** (0.050)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.0789 (0.064)
Applied, Life, Hard			-0.0404 (0.11)
Applied, Non-Life, Hard			-0.0417 (0.058)
Doctoral Degree (Reference)			
Master's Degree			-0.0585 (0.054)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			0.0807 (0.051)
Constant	3.709*** (0.031)	3.179*** (0.11)	3.289*** (0.13)
Adjusted <i>R</i> ²	0.02	0.05	0.05

Note: Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Research Question 5: Relationship between Cultural Congruity
and Connections with Cultural Representatives

The aim of research question five was to understand the relationships between international graduate students' levels of cultural congruity and perceived levels of connections with cultural representatives. The following models were used to test these relationships:

Model 1: $Y = \text{Gender} + \text{Race/Ethnicity}$

Model 2: $Y = \text{Model 1} + \text{Focal variables}$

Model 3: $Y = \text{Model 2} + \text{strong set of controls}$

One set of OLS regression models were used to estimate the extent of international graduate students' cultural congruity predicts strong connections with cultural representatives are in Table 4.8. Like the first series of analysis, I regressed connections with cultural representatives on gender and race. The F-test for Model 1 suggests that the model is significant in explaining some of the variance in international graduate students' connection with cultural representatives ($R^2 = .02$, $F_{6, 946} = 4.92$, $p < .01$). The significance of the variables in Model 1 persists through Model 3 ($R^2 = .04$, $F_{14, 938} = 3.36$, $p < .01$). Important to consider is that the explanatory power between the models increases minimally indicating that the added variables in Model 2 and Model 3 do not substantively improve the explanatory power of international graduate students' connections with cultural representatives, even with the additional control variables.

Model 1 examining the relationships between gender and race/ethnicity with international graduate students' connections with cultural representatives, the data reveal

that White/Caucasian students ($b = -.167^{**}$, $se = 0.07$) have lower connections with cultural representatives than Asian/Pacific Islander students. Conversely, Black/African students ($b = .399^{***}$, $se = 0.12$) and Hispanic/Latino/a students ($b = 0.242^{***}$, $se = 0.08$) have stronger connections than Asian/Pacific Islander students, the reference group. Barring a decrease in significance for White/Caucasian students ($b = -.206^{**}$, $se = 0.07$) these findings in racial differences persisted in Models 2 and Model 3.

In Model 2 cultural congruity is associated positively with international students' connections with cultural representatives ($b = 0.053^{**}$, $se = 0.02$). On average, international students report cultural congruity is positively associated with stronger connections with cultural representatives. Stronger connections with cultural representatives are higher if they also report higher levels of cultural congruity in Model 3 ($b = .045^{**}$, $se = 0.23$). I test the robustness of these relationships by including the additional individual and background controls in the regression equation. Here, the results remain consistent for cultural congruity.

Of the background characteristics those students who do not seek advisor guidance ($b = -.115^{**}$, $se = .05$) display lower connections with cultural representatives when compared to students who do seek advisor guidance. Students who attend R2 institutions ($b = .089^{*}$, $se = .05$) report stronger connections with cultural representatives than those students who attend R1 institutions. Background characteristics have minimal explanatory power in explaining the extent to which IGS' connections with cultural representatives are impacted by the addition of control variables. variables, as R-square only increased by .01 from model 2 and Model 3. The full model explained 4% of this

linear combination of variables. The last multiple regression was performed to evaluate the relationship between international students' connections with cultural representatives and identity.

Table 4.8. Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Cultural Congruity (n = 953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Cultural Congruity		0.053** (0.02)	0.045** (0.02)
Male (Reference)			
Female	0.0455 (0.04)	0.043 (0.04)	0.029 (0.04)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.167** (0.073)	-0.180** (0.073)	-0.206*** (0.074)
Arab/Middle Easterner	-0.00729 (0.086)	-0.00774 (0.086)	-0.0230 (0.087)
Black/African	0.399*** (0.12)	0.390*** (0.12)	0.357*** (0.12)
Hispanic/Latino/a	0.242*** (0.077)	0.220*** (0.077)	0.186** (0.078)
Other	0.00442 (0.088)	-0.0113 (0.087)	-0.0280 (0.087)
Year			0.00765 (0.015)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.115** (0.051)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.0852 (0.065)
Applied, Life, Hard			-0.0453 (0.11)
Applied, Non-Life, Hard			-0.0469 (0.059)
Doctoral Degree (Reference)			
Master's Degree			-0.0604 (0.054)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			0.089* (0.051)
Constant	3.709*** (0.03)	3.444*** (0.11)	3.545*** (0.13)
Adjusted R ²	0.02	0.03	0.04

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Research Question 6: Relationship between Identity Prominence
and Connections with Cultural Representatives

The final set of models examine the strength and direction of the relationship between international graduate students' identity prominence and their perceived connections with cultural representatives. The analysis is again presented in three models: the first model considers only demographic characteristics, then added to the model are social and professional identity, and in the final model a strong set of controls. For Model 1, the F-test was found statistically significant ($R^2 = .02$, $F_{6, 946} = 4.88$, $p < .01$). When the main focal variables were added to Model 2 and the control variables in Model 3 the models remained significant ($R^2 = .07$, $F_{15, 937} = 5.75$, $p < .01$).

Again, White/Caucasian students ($b = -.167^{**}$, $se = .07$) have lower connections with cultural representatives when compared to Asian/Pacific Islander students. Whereas, Black/African students ($b = .399^{***}$, $se = .07$) and Hispanic/Latino/a students ($b = .242^{***}$, $se = .08$) have stronger connections with cultural representatives compared to Asian/Pacific Islander students. This significance persisted in Model 2 and 3. Alternatively, White/Caucasian students who report lower connections with cultural representatives is nonsignificant in Models 2 and 3. Social identity ($b = .064^{**}$, $se = .03$) and professional identity ($b = .147^{***}$, $se = .04$) are associated with stronger connections with cultural representatives and remain significant in Model 3 for social identity ($b = .066^{***}$, $se = .03$) and professional identity ($b = .137^{***}$, $se = .03$).

The presence of the background characteristics in Model 3 did not add much to explain the relationships. Of the background characteristics those students who do not

seek advisor guidance ($b = -.110^{**}$, $se = .05$) display lower connections with cultural representatives when compared to students who do seek advisor guidance.

The overall model fit was significant across all three models. Each addition of variables improved the model's explanatory power from less than 3% of variance explained in Model 1, to 6% in Model 2, to an incremental .01 increase where 7% of the variance can explained in the full model. Both social and professional identity positively influence connections with cultural representatives, though professional identity seems more important than social identity in predicting stronger connections.

Table 4.9. Unstandardized OLS Regression Coefficients for International Graduate Students' Connections with Cultural Representatives on Identity Prominence (n = 953).

	Model 1 <i>b</i> (se)	Model 2 <i>b</i> (se)	Model 3 <i>b</i> (se)
Social Identity		0.064** (0.03)	0.066*** (0.024)
Professional Identity		0.147*** (0.035)	0.137*** (0.034)
Male (Reference)			
Female	0.0455 (0.043)	0.0333 (0.043)	0.0216 (0.043)
Asian Pacific Islander (Reference)			
White/Caucasian	-0.167** (0.073)	-0.0907 (0.075)	-0.119 (0.073)
Arab/Middle Easterner	-0.00729 (0.084)	-0.0282 (0.082)	-0.0414 (0.085)
Black/African	0.399*** (0.12)	0.306*** (0.11)	0.281** (0.12)
Hispanic/Latino/a	0.242*** (0.075)	0.278*** (0.075)	0.246*** (0.077)
Other	0.00442 (0.094)	0.00899 (0.090)	-0.00816 (0.086)
Year			0.0118 (0.015)
Seeks Advisor Guidance (Reference)			
Does Not Seek Advisor Guidance			-0.110** (0.050)
Pure, Life, Hard (Reference)			
Pure, Non-Life, Hard			-0.0595 (0.064)
Applied, Life, Hard			-0.0345 (0.11)
Applied, Non-Life, Hard			-0.0279 (0.058)
Doctoral Degree (Reference)			
Master's Degree			-0.0597 (0.053)
Highest Research Activity, R1 (Reference)			
Higher Research Activity, R2			0.0828 (0.050)
Constant	3.71*** (0.03)	2.87*** (0.14)	2.93*** (0.16)
Adjusted <i>R</i> ²	0.02	0.06	0.07

Note: Standard errors in parentheses *** *p*<0.01, ** *p*<0.05, * *p*<0.10

Chapter Four Summary: Results

This multiple regression study examined the extent international graduate students' mentor and peer relationships, cultural fit, and identity formation influence intercultural relevancy as parts of the socialization process. Correlation and multiple regression analyses were conducted to examine the relationship between levels of intercultural relevancy in STEM and various potential explanatory variables. Fields (2009) recommends hierarchical regression method for model building in the social sciences. Ordinary least squares regression (OLS) was chosen for this study because it is considered a robust technique that can tolerate small violations in its' assumptions (Cohen et. al, 2003; Fields, 2009; Mehmetoglu & Jakobsen, 2017). OLS estimations show the strength and direction of the relationship for each outcome variable on several explanatory variables. This research study examined the possible associations between international graduate students' intercultural relevancy in STEM, social interactions, cultural congruity, and identity are related as parts of the socialization process at American public research universities. Relationships between intercultural relevancy and other socialization factors were evaluated through a hierarchical model building approach using robust regression. Overall, OLS analysis of all respondents (n = 953) revealed four of the five explanatory variables — mentors' cultural support, peer interactions, social identity and professional identity are positively associated with cultural integrity in STEM. For the second set, five of the six explanatory variables — mentors' cultural support, peer interactions, cultural congruity, social identity and professional identity are positively associated with connections with cultural representatives at American public

research universities. Social identity had the largest effect size, followed by mentors' cultural support ($b = .35$, $p = .001$), mentors' academic support ($b = .33$, $p = .001$).

In sum, positive levels of connections with cultural representatives are significantly correlated with higher levels of social interactions and identity prominence, indicating that those with higher levels on these variables tend to value cultural connections with cultural representatives.

CHAPTER FIVE

CONCLUSIONS

Introduction

This quantitative study examined the extent that STEM international graduate students' social interactions with their faculty mentors and peers, cultural congruity, and identity prominence influence their intercultural relevancy as parts of the socialization process at American public research universities. Intercultural relevancy in STEM refers to the extent to which an individual perceives the degree of importance that others, the campus, and the STEM research environment value their cultural background. As a diverse population, international graduate students view of socialization can provide some unique insights into social norms, attitudes, and values enacted in STEM research environments at American public research universities.

In this last chapter, I present the findings of this study and relate those findings to the literature on international graduate students. Implications of the study are shared, and connections are drawn to issues pertinent to international education, higher education scholars, and stakeholders of graduate education. I discuss the limitations of the study, some recommendations for future research, and close the study with a summary of the study. Next, I outline the research questions, theoretical framework, and study methods.

Overview

International graduate students experience some common challenges during their graduate training at American public research universities (J. J. Lee & Rice, 2007; Szelényi & Rhoads, 2007; Todoran, 2018; Wang, 2009; Yuchun Zhou, Frey, & Bang, 2011). One of the challenges international students face in graduate school relates to cultivating and sustaining positive relationships with their faculty mentor and peers (Glass et al., 2015; Hendrickson et al., 2011; Rose-Redwood & Rose-Redwood, 2013; Trice, 2003, 2004; Trice & Yoo, 2007). Further, cultural isolation and travel difficulties between host and home country are other unique challenges international graduate students meet as sojourners studying in the U.S. (Bhattacharyya, 2017; Contreras-Aguirre & Gonzalez Y Gonzalez, 2017; McLachlan & Justice, 2009). Another challenge highlighted globally relates to the role that identity formation plays in the socialization of international graduate students at universities in the Australia, Canada, China, New Zealand, and the United States (Campbell & Prins, 2016; Cotterall, 2015; Fotovatian, 2012; Manathunga, 2011; Marginson, 2013; Phelps, 2016; Szelényi & Rhoads, 2007).

The theoretical home of this study is socialization. Socialization serves as an umbrella term for the variables under study. Socialization is a process where one seeks membership into a group or social structure through interaction with that group or social structure(s). The assimilative process frequently involves the adoption, and subsequent internalization of knowledge, attitudes, behaviors, and values of the in-group (i.e., academic discipline) (Bragg, 1976; Brim, 1966; Coombs, 1978; Merton, Reader, & Kendall, 1957; Weidman & Stein, 2003).

An intercultural perspective was the basis for the intercultural relevancy in STEM scale. Museus and Quaye (2009) recommended the inclusion of other meaningful perspectives for research concerning minority undergraduate student. The two concepts under study in this dissertation include cultural integrity, and collective and individual cultural agents (Museus & Maramba, 2010; Museus & Quaye, 2009; Rendón et al., 2000; Tierney, 1999). I renamed the survey constructs to cultural integrity in STEM and connections with cultural representatives as those terms capture the measure and meaning of the items. Cultural integrity in STEM is the degree to which a person's cultural identity is honored and promoted as they interact within and engage with others in alien environments (Andrade, 2006a; Museus & Quaye, 2009; Tierney, 1999). Connections with cultural representatives signify cultural relationships on campus that provide social and cultural support to a person from someone who comes from the same culture, also known as individual and collective (Museus & Neville, 2012; Museus & Quaye, 2009; Museus, Shiroma, & Dizon, 2016). The scale intended to measure students' perceptions about the value of cultural representatives in the graduate education milieu.

These two related lines of inquiry inform the analytical lens and method of my study that examined the socialization experiences of international graduate students from a cultural perspective. Further, intercultural studies informed my theoretical lens (Hammer et al., 2003; Y. Y. Kim, 2001, 2008). Three concepts that shaped the development of my analytical lens authored works that expanded cultural perspectives for higher education research and intercultural studies.

Further, the explanatory variables are the mentor's cultural and academic support, peer interactions, cultural congruity, and identity prominence. Social interactions, a somewhat abstract notion, is defined in this study as the day to day communications, verbal and non-verbal, with other people from our immediate research sphere of influence. Additionally, cultural congruity represents students' perceived value of their culture in the new environment, the alignment between the new culture and their culture of origin, and the degree to which a university supports the unique needs of students. Lastly, identity prominence reflects the perceived level of importance individuals place on their identities at any given time. Identity is defined as the most public self, encompassing professional and social self-concepts (Hogg et al., 1995). Identities are both established and in flux. Identity is a critical aspect of the multi-faceted acculturation and socialization process (Tian & Lowe, 2013). In this next section, I briefly describe the methods and responses to the research questions.

Methodology

The goal of the work is to contribute empirical understanding about the factors that influence international graduate students' intercultural relevancy in STEM. The literature review informed critical decision making in research design, such as question development, construct measures, and my analytic approach (Conway, 2015; Stage, 2007; Teranishi, 2007). Three theoretical domains shaped the design of the study — graduate student socialization, intercultural studies, and social psychological theory. Once I refined research questions, I selected the most appropriate constructs to answer

each question. The secondary data came from a sample of international graduate students who chose to participate in the PNW-COSMOS Graduate Student Experiences (GSE) survey (Hollist, 2017). The GSE survey covered a range of topics associated with graduate students' socialization experiences in STEM. Scales from validated instruments included cultural congruity, environmental fit, and peer and mentoring relationship, see Appendix C. My involvement as a member of the research team that developed this survey instrument gave me access and permission to use this data for my study. The GSE survey was administered to all graduate students in STEM at twelve research institutions from 2015-2017. The data for this study came from the 953 international graduate students who participated in the survey.

The latent outcome variable of this study was intercultural relevancy in STEM which was operationalized as two variables — cultural integrity and connections with cultural representatives. As a multiple regression study, the research questions were designed to determine the extent international graduate students' mentor and peer relationships, cultural fit, and identity formation influence intercultural relevancy as parts of the socialization process. To address my research questions, statistical analyses were completed using ordinary least squares regression (OLS), I entered blocks of variables sequentially to the regression model. I estimated two series of OLS models. The first outcome variable, cultural integrity in STEM, was regressed on the respective explanatory variables — mentor's cultural support, mentor's academic support, peer interactions, cultural congruity, social and professional identity prominence while

holding controls constant. The second outcome variable, connections with cultural representatives was regressed on those same explanatory variables.

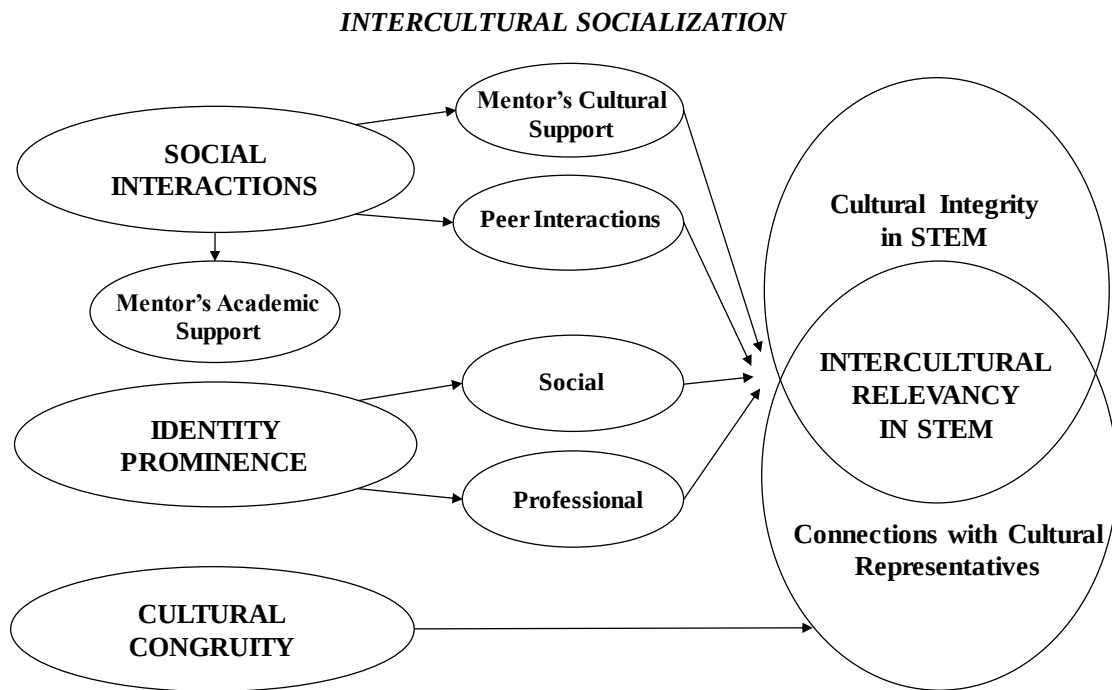


Figure 5.1 Revised model intercultural socialization of STEM international graduate students at American public research universities.

Discussion of the Results

The overarching goal of the research is to more fully understand how STEM international graduate students perceive their graduate experiences at American public research universities. This specific aim was to examine the influence of international graduate students' mentors' support, peer interactions, cultural congruity, and identity prominence on intercultural relevancy in STEM. In the next section, I present the findings from the two series of regression models. The analysis also shows demographic

and background characteristic differ somewhat across groups. I compared regression results and findings to previous studies on international graduate students' experiences.

The first series of regression results found students who report higher levels of cultural integrity in STEM are positively associated with mentor's cultural support, peer interactions, social and professional identity prominence, but not with mentors' academic support or cultural congruity. The second series of regression results found that students who report stronger connections with cultural representatives are positively associated with mentor's cultural support, peer interactions, cultural congruity, social and professional identity, however mentors' academic support is not statistically significant.

Dependent Variable: Cultural Integrity in STEM

Cultural integrity is the degree to which an individuals' cultural identity is honored and promoted as they interact within and engage with others in alien environments (Museus & Maramba, 2010; Museus & Quaye, 2009; Tierney, 1999; Tierney & Jun, 2001). The examination of the first three constructs revealed that mentors' cultural support, peer interactions, and social identity are statistically significant and explain a small amount of variance among this combination of variables on cultural integrity in STEM.

Research Question 1: Relationship between Social Interactions
and Cultural Integrity in STEM

To what extent do STEM international graduate students' social interactions with their faculty mentors and peers influence their cultural integrity in STEM at American public research universities?

One unique contribution of my study was the differentiation made between faculty advisors' role in cultural support and academic advising. The findings showed a positive association between mentors' cultural support and students perceived levels of cultural integrity. The mentors' cultural support explained 8% of the variance in the students' levels of Cultural Integrity in STEM. Conversely, mentors' academic support was not significantly associated with cultural integrity in STEM. This finding on mentors' cultural support is consistent with several research studies on the critical role of the advising behaviors on a sense of belonging and cultural integration (Trice & Yoo, 2007; Zhao et al., 2007). Consistently in the literature on international graduate students, researchers have found the advisor-advisee mentoring relationship critical to graduate student success, completion, and professional integration (Crede & Borrego, 2014; Curtin et al., 2013; George et al., 2018; Knox et al., 2013; Prime et al., 2014; Rice et al., 2009). Since we know the advisor's role is critical to the well-being and success of international graduate students, I chose to treat mentors' cultural support and mentors' academic support as distinct constructs (Cotterall, 2015; Fotovatian, 2012; Manathunga, 2011). Unlike other studies on International students in the United States this study does not compare international students to domestic U.S. students ("H-1B Visas Help Employers, Hurt U.S. Labor,," 2017). However, another comparison study found faculty advisor

support was positively associated to both higher levels of sense of belonging in the department and positive professional self-concept for both international and domestic students (Curtin et al., 2013). Further, there are mixed findings in the literature between the role that culture plays in international students' experiences with their advisors. On the one hand my findings on the importance of mentors' cultural support of students' cultural integrity in STEM is consistent with the positive findings found on the benefits of intercultural supervision (Kidman, Manathunga, & Cornforth, 2017; Manathunga, 2011). Both studies indicated that communication difficulties arose when faculty essentialized cultural differences between themselves and their international student advisees. For example, Manathunga (2011) found communication difficulties between advisor and advisee were triggered by misread verbal and social cues a qualitative study that explored intercultural supervision involved three Engineering supervisors and their four doctoral advisees. This essentialization of all students from non-European backgrounds as requiring the same treatment led to false assumptions and frustrated students. These findings draw critical attention to the importance of intercultural learning for both advisors and students working together in graduate environments.

One potential explanation for the conflicting findings in the literature about the advisor-advisee mentoring relationship may be explained by the frequent treatment of advising and mentoring as a single construct (Lott, Gardner, & Powers, 2009; Lunsford, 2012). Treating advising and mentoring as one construct is problematic because the advisor-advisee mentoring relationship is not one dimensional. When a scale combines two multiple dimensions, it fails to capture differential aspects of the advisor-advisee

mentoring relationship. Mentoring encompasses different kinds of support like academic or career-related, and other supports related to psychosocial needs (Lunsford, 2012). Faculty advisors may, or may not provide, both supports to advisees, or perhaps even, all types of support to advisees. Further the expectations of which supports and the degree of support given varies across disciplines and institutional types (Gardner, 2010b, 2010a).

Peer interaction is the subject of the second part of the research question on international graduate students' perception of cultural integrity in STEM. I found that peer interaction was positively associated with cultural integrity in STEM. The peer interaction explained 7% of the variance in the students' levels of Cultural Integrity in STEM. In my study peer interaction was characterized by items such as, 'My interpersonal relationships with other students have had a positive influence on my personal growth, attitudes, and values', Peer support is considered important to their intercultural learning (Gomes & Tran, 2017; Guo & Chase, 2011; Hendrickson et al., 2011; Sawir, 2013). This finding supports recent research that found peer interaction influential on cultural belonging (Allan, 2003; Trice, 2004). One Australian study used hierarchical regression analysis on 190 (76 male and 113 female) Asian international students. Their results determined that cultural inclusiveness and quality of contact were significant predictors of intercultural attitudes (Tawagi & Mak, 2015). Padilla and Perez (2003) found that the individual's cultural competence was "the learned ability to function in a culture in a manner that is congruent with the values, beliefs, customs, mannerisms, and language of the majority of members of the cultural" (p. 42). Their understandings support other research that found among co-national and domestic

students, peer support positively influenced cultural integrity in STEM. (Fries-Britt et al., 2014; Malone & Barabino, 2009; Rose-Redwood & Rose-Redwood, 2013; Trice, 2004). Peers interaction and cultural integrity warrant more research in the literature on graduate student socialization in the United States.

Research Question 2: Relationship between Cultural Congruity and Cultural Integrity in STEM

To what extent do STEM international graduate students' levels cultural congruity influence cultural integrity in STEM at American public research universities?

In research question two, cultural congruity is not significantly associated with cultural integrity in STEM. Cultural congruity explained 3% of the variance in the students' levels of cultural integrity in STEM. This lack of relationship between international graduate students perceived levels of cultural congruity and cultural integrity in STEM was surprising based on prior research. This finding is contrary to findings from past research on cultural congruity and sense of belonging. Gloria et al. (2005), found that cultural congruity and positive coping strategies were the strongest predictors of psychological well-being for Latino/as undergraduate college students. We know from the research that international graduate students also encounter racism and discriminatory practices by their physical attributes, cultural ways, and home country's relationship with the United States (George Mwangi, Changamire, & Mosselson, 2018; J. J. Lee & Rice, 2007). Lieb (2007) demonstrated that higher levels of cultural congruity could influence cultural adjustment and well-being for international students. This finding is similar to Gloria et al.'s (2016) reliability and validity study that found cultural

congruity and the university environment scales appropriate for Latino/a and Hispanic, Chicano/a students. In this study this diverse racial population is referred to as Hispanic/Latino/a. The significance of racial groups and the directionality support these assertions that specific ethnic groups should not be treated in a “one size fits all” and that valid and reliable measures are needed to better understand the differential experiences across ethnic groups. Though cultural congruity was not a positive predictor of cultural integrity in STEM in my sample, and counters past research. Perhaps this finding indicates students who have higher levels of cultural congruity may not place as much importance on the need to have cultural fit in a professional research setting.

Research Question 3: Relationship between Identity and Cultural Integrity in STEM

To what extent do STEM international graduate students’ social and professional identity prominence influence their cultural integrity in STEM at American public research universities?

Identity prominences were operationalized into two variables — social and professional identity. International students’ strength of social identity was positively associated with higher levels of cultural integrity in STEM. Identity prominence explained 7% of the variance in the students’ levels of cultural integrity in STEM. Social identity was characterized by a students’ ‘Being identified as a member of the family I grew up with’, ‘Being identified as a member of the community where I grew up.’. Whereas professional identity was related to students ‘Being identified as someone who shares their knowledge with their community’ and ‘Being identified as a scientist.’

Identity prominence was measured on a five-point Likert scale of importance. The measure asked students to select the level of importance they assign to professional declarations. International students' strength of social identity and professional identity were both positively associated with higher levels of cultural integrity in STEM. However, social identity was a stronger predictor of cultural integrity in STEM than professional identity. Identity research also finds that interaction with close others (the proximate social structure) influences the salience of identity and behavior associated with the identity (Merolla, Serpe, Stryker, & Schultz, 2012). When social identity and professional identity were added to the model, both were found statistically significant and positively associated with cultural integrity experiences in STEM. Social identity is considered more significant than professional identity; a finding that remained consistent in the model. A pattern emerged from the results that seem to indicate international students' who place more importance on their social identity in the STEM research context have higher levels of cultural integrity.

Outcome Variable One Demographic and Background Characteristics

The patterns for the relationships between the international graduate students' demographic and background characteristics and their perceived levels of cultural integrity were similar across each analysis of the focal independent variable including mentor interaction, peer interaction, cultural congruity, and identity prominence. In all the analyses there was no significant relationship between gender and cultural integrity in STEM. The significant racial differences on cultural integrity for the analyses including

mentors' interaction, peer interaction, and cultural congruity were consistent.

Interestingly, this pattern did not persist in the analysis of identity prominence. In the analysis between identity prominence and cultural integrity in STEM, Black/African students and Hispanic/Latino/a students had higher levels of cultural integrity in STEM than Asians, though White/Caucasian students still had lower levels of cultural integrity than Asians.

These patterns are interesting for two notable differences in the role that international students' race played in the mentors' cultural support and students' cultural integrity. White/Caucasian students and Hispanic/Latino/a students had lower levels of cultural integrity in STEM than Asians. This finding is interesting in light of previous research that found Asian international students are less likely to seek out support services (J. Y. Lee & Ciftci, 2014; Lieb, 2016). Moreover, another study found that Asian doctoral students in STEM perceived the advisor relationship as critical and were burdened by funding concerns and dependence upon their advisor (Le & Gardner, 2010). This finding is also of some interest as more recent studies have shown that Asian international students are more likely to attend American institutions where other Asian students enroll (Mazzarol & Soutar, 2002). Asian students may also have more opportunities to join a lab where their faculty advisor is from a similar background because they represent the largest racial group who come to the U.S for graduate studies (Chang & Kono, 2014).

Finally, the patterns for international graduate students' degree program and seeking advisor help also remained consistent for cultural integrity in STEM across all

the analyses of the primary independent variables. Those students who were pursuing a master's degree had higher levels of cultural integrity compared to doctoral degree students. Also, those students who were more likely to seek their advisors for help had higher levels of cultural integrity than students who did not seek out their advisor. One unique pattern observed in the analyses between identity prominence and levels of cultural integrity in STEM was the relationship between institutional type. International graduate students who attend R2 institutions report higher levels of cultural integrity in STEM than those students who attend R1 institutions. The degree findings for students who are pursuing a master's degree compared to those pursuing a doctoral degree had higher levels of cultural integrity in STEM. This finding may explain the work habits of doctoral students who tend to work independently and may be more focused on academic success as compared to cultural aspects of the STEM environment. This assertion is speculative as studies have yet to explicitly address the relationship between degree programs and cultural integrity in STEM.

Dependent Variable: Connections with Cultural Representatives

Connections with cultural representatives represent those cultural relationships on campus that provide social and cultural support to a person from someone who comes from a similar cultural background as them (Museus & Maramba, 2010; Museus & Quaye, 2009; Tierney, 1999; Tierney & Jun, 2001). The second set of models indicated that mentors' cultural support, peer interactions, cultural congruity, social identity, and

professional identity were positively associated with levels of international graduate students' connections with cultural representatives.

Research Question 4: Relationship between Social Interactions and Connections with Cultural Representatives

To what extent do STEM international graduate students' social interactions with their faculty mentors and peers influence connections with cultural representatives at American public research universities?

This study indicates that mentors' cultural support is significantly related to connections with a cultural representative. The mentors' cultural support explained 6% of the variance in the students' importance of connections to cultural representatives. Mentors' cultural support was found statistically significant, in terms of practical significance I would argue that these findings can be considered practically significant. We know from the literature that the advising relationship is central to graduate student success and completion (Crede & Borrego, 2014; Curtin et al., 2013). Moreover, the results of this study seem to indicate that the mentors' advising behavior has no association with connections with cultural representatives. The mentors' academic support scale included questions related to the professional behaviors of a mentor and not necessarily the cultural support of the whole person. Results interpreted through an intercultural framework support these findings. We know from the literature that the advisor-advisee relationship is instrumental to students' integration to the academic community, but we know less about mentors' social and culturally responsive behaviors that help to mediate any cultural isolation students may experience. Mentor's cultural

support is important to connections with cultural representatives. Whereas mentor's academic support is not associated with connections to cultural representatives. This finding is not surprising given that students who value their mentors' showing of cultural interest also place value on making connections with others from a similar culture (Tincu, 2009). Rice et al.'s mixed-methods study found international graduate students' associations between academic grades and other characteristics were minimally associated with their advisory alliance scores (Schlosser & Gelso, 2001). Conversely, the study found advisor satisfaction and the want to switch advisors was greatly associated with their alliance inventory scores. Lastly, their qualitative findings described international graduate students' advising experiences as mostly damaging and less constructive (p. 385). Rice et al. study aligns with my findings for this research question. Both of these findings may suggest international graduate students have unique needs that may go beyond academic support to needing more cultural support to feel a sense of belonging (Fries-Britt et al., 2014; George Mwangi, Changamire, et al., 2018; Knox, Moskovitz, Schlosser, & Hill, 2006; J. J. Lee & Rice, 2007; Rice et al., 2009; Yao, 2018)

Peer interactions in a separate analysis is positively associated with international graduate students' who report stronger connections with cultural representatives in a second set of analyses. Peer interactions explained 5% of the variance in the students' connections to cultural representatives. This finding indicates that students who have higher levels of peer interactions also tend to value cultural connections with people which is also consistent with the literature (Hendrickson et al., 2011; Rose-Redwood & Rose-Redwood, 2013; Trice, 2004) For example, studies have shown peer interaction

international graduate students experience influences well-being and cultural adjustment (Curtin et al., 2013; Mallinckrodt & Leong, 1992; Trice, 2004; Trice & Yoo, 2007).

Research has differed on which peer group (i.e., co-nationals, nationals, domestic) impacts cultural integrity and sense of belonging for these students and the duration of these kinds of relationships (Rui & Wang, 2015).

Research Question 5: Relationship between Cultural Congruity and Connections with Cultural Representatives

To what extent do STEM international graduate students' cultural congruity influence their connections with cultural representatives at American public research universities?

My findings indicate a very weak relationship between international students perceived level of cultural congruity and the importance in which they place on connections with cultural representatives. This metric is based on a Likert 5-point scale of importance. Cultural congruity was the only explanatory variable and significantly associated with connections with cultural representatives, which I assumed a positive relationship would exist. This could reflect the influence advisors have on student social and professional engagement. Perhaps students who seek less support also do not seek cultural interaction. Another possibility is that cultural representatives who they identify with are not present or known in the campus community.

Research Question 6: Relationship between Identity
and Connections with Cultural Representatives

To what extent do STEM international graduate students' social and professional identity influence their connections with cultural representatives at American public research universities?

This study found that identity prominence was positively associated with connections with cultural representatives. Identity prominence was measured by the strength of the students' professional and social identity. My findings indicate a significant relationship between both the international graduate students social and professional identity and its relationship to the importance of connections with cultural representatives on campus. Moreover, the findings indicate that professional identity was a stronger predictor of the importance in which a student placed on their connections with individuals from with similar cultural backgrounds. Studies looking at international graduate student identity formation at universities in Australia and New Zealand have found of great importance to intercultural relations (Fotovatian, 2012; Manathunga, 2011; Marginson, 2013). This work supports my finding that international graduate students' high levels of professional and social identity prominence are positively associated with stronger connections with cultural representatives and perhaps have student agency and self-efficacy (Poyrazli, 2003; Rose-Redwood & Rose-Redwood, 2013). Their higher professional self-concept may mean they have more confidence to find cultural support. Another possibility could be that the longer one is engaged in doctoral studies the longer that individual is separated from home and therefore, cultural congruity decreases (Gardner, 2009a; Gomes & Tran, 2017). This finding warrants further investigation.

Marginson (2013) argues for a paradigm shift in the way we do socio-cultural research on international students and education

from understanding international education as a process of “adjustment” of foreign students to local requirements, which is the paradigm that currently dominates research on international students, to understanding international education as self-formation. (p. 7)

These findings may capture other aspects of socialization not as prevalent in the literature. The role of connections to cultural representatives may play an important part in professional and social identity development in graduate students as part of the socialization process (Gardner, 2009b; Terrell, Snyder, & Dringus, 2009; Ward, 2010).

Outcome Variable Two Demographic and Background Characteristics

Like cultural integrity in STEM, the relationships between the international graduate students’ demographic and background characteristics and their perceived levels of connections with cultural representatives were similar across each analyses of the focal independent variable including mentor interaction, peer interaction, cultural congruity and identity prominence. In all the analyses there was no significant relationship between gender and connections with cultural representatives. The significant racial differences on cultural integrity for the analyses including mentors’ interaction, peer interaction, and cultural congruity were consistent. Interestingly, this pattern did not persist in the analysis on identity prominence. In the analysis between identity prominence and connections with cultural representatives, Black/African students and Hispanic/Latino/a students had higher levels of connections with cultural representatives than Asians, though White/Caucasian students still had lower levels of connections with cultural

representatives than Asians. There were the same differences in racial patterns for all the other explanatory variables. White students had weaker connections to cultural representatives than Asian students; and Black/African students and Hispanic/Latino/a students had stronger connections. This finding suggests that international students from more European backgrounds may not require as much connection to culture within American higher education, that assumes that the White students who participated in this study come from that part of the world. Further, this finding is also interesting in light of previous research that found Asian international students are less likely to seek out support services (J. Y. Lee & Ciftci, 2014; Lieb, 2016). Another study found Asian doctoral students in STEM perceived the advisor relationship as critical and were burdened by funding concerns and a their dependence upon their advisor (Le & Gardner, 2010). This finding is also of some interest as more recent studies have shown that Asian international students are more likely to attend American institutions where more Asian students enroll (Mazzarol & Soutar, 2002). Asian students may also have more opportunities to join a lab where their faculty advisor is from a similar background because they represent the largest racial group who come to the U.S for graduate studies (Chang & Kono, 2014).

The background characteristics also remained consistent for connections with cultural representatives across all the analyses of the primary independent variables. Those students who do not seek advisor guidance display lower connections with cultural representatives when compared to students who do seek advisor guidance students

The same stays true for degree program, those who were pursuing a master's degree program had higher levels of connections with cultural representatives compared to those pursuing a doctoral degree. Students enrolled at an R2 institution have stronger connections with cultural representatives compared to students from an R1 institution.

Summary of Results

I relied on an intercultural perspective to better understand international graduate student socialization at public research universities. One unique aspect of this study was the reliance on an intercultural perspective to understand international graduate students' experiences at American public research universities. The study developed the concept of intercultural relevancy based on the primary literature of Museus and Quaye (2009) and Kuh and Love (2001). These researchers interviewed 30 students of color at a large rural public research university about the influence of campus cultures in the experiences of students of color. Their findings resulted as a revised version of the cultural propositions (Kuh & Love, 2009). Further, Museus and Quaye added two important concepts to Kuh and Love's intercultural propositions which included the role of cultural agents and cultural integrity. This study adopted both terms though cultural integrity in STEM and connections with cultural representatives. Cultural integrity is the degree to which a person's cultural identity is honored and promoted as they interact within and engage with others in alien environments (Andrade, 2006a; Museus & Quaye, 2009; Tierney, 1999). The notion connections with cultural representatives signifies those cultural relationships on campus that provide social and cultural support to a person from

someone who comes from the same culture, also known as institutional agents (Bourdieu, 1985; Museus & Maramba, 2010; Museus & Quaye, 2009). This construct measures students' perceptions about the value of cultural representatives in the graduate education milieu.

This study aimed to understand the influence of social interactions, cultural congruity, and identity prominence on international graduate students' cultural integrity in STEM and connections with cultural representatives at American research universities. This study supports the idea international graduate students' intercultural relevancy is associated with other parts of socialization. Although, the degree of practical significance needs further study, the adjusted R square effect size for the full model ranged from between .03 and .10 respectively. Mentors' cultural support, peer interactions, and identity prominence had greater explanatory power for connections to cultural representatives than for cultural integrity. The connections to cultural representatives assessed the quality and quantity of connections with other people from similar backgrounds. The cultural integrity asked people to assess their experiences with culture, a term that has multiple meaning and is somewhat abstract. Participants may have found these items less understandable.

The significant influence of the mentor's cultural support shows that there are cultural and social facets of the graduate socialization process, which is supported by some of the more recent research and the importance of intercultural supervision. A series of studies have recently come out about international graduate students and intercultural supervision. Manathunga (2011) asserts, "all supervisors need to engage with

intercultural supervision and that we need to develop a complex understanding of culture that goes beyond cultural stereotypes.” (p. 374). Follow up studies of this research found intercultural supervision effective and culturally responsive advising impactful for international students (Fotovatian & Miller, 2014; Kidman, Manathunga, & Cornforth, 2017). For example, Trice (2007) concluded that peer interactions had a significant and positive effect. Students' with stronger connections with cultural representatives are also positively associated with mentors' cultural support, peer interactions, cultural congruity, and both social and professional identity but not with mentors' academic support.

Findings from this study support the notion that faculty mentors' cultural support and peer interaction influence the socialization process for international students' intercultural relevancy in STEM. The multidimensional constructs that characterized parts of socialization were developed from intercultural perspectives, social psychology and graduate education research. If we think of research and graduate education from an intercultural perspective, this study's findings on STEM international graduate students' experiences along with other research efforts show the complexity of a student's cultural perceptions of integrity in STEM and connections with individuals from similar cultures.

The results of the study indicated that mentor's cultural support, peer interactions, cultural congruity, social and professional identity had significant positive effects on international graduate students' cultural integrity in STEM. These findings suggest mentor's cultural support, peer interactions, social and professional identity are important for developing intercultural relevancy within international graduate students. But more importantly culture and students' relationships with culture differ across groups.

Research on international graduate students has seen an increase in studies that are looking at intercultural supervision and the effects on both faculty mentor and mentee (Elliot, Baumfield, & Reid, 2016; Manathunga, 2011; Linlin Xu & Grant, 2017). The results of research question one of this study support some recent findings related to intercultural studies. Manathunga (2017) found graduate students relationships with faculty mentors and peers are critical to graduate student success. Although mentors' academic behaviors were found nonsignificant on cultural integrity in this study, I view this finding as counter to what we know about this relationship from the literature. Other research found that both the advising and peer relationships contribute to positive academic and social interactions. Further, this findings may show the distinct benefits of cultural and social interaction on cultural integrity and well-being for international students (Tincu, 2009; Trice, 2004; Zhao et al., 2007).

My study attempted to employ measures of agency, such as cultural integrity and connections to cultural representatives, to better capture students' perceptions toward cultural aspects of socialization. Though limited in its design and statistical prowess, steps have been made in capturing baseline data of this special population and initial findings that warrant further research and instrument development. Other findings in the literature found that the influence of cultural congruity and psychosocial and cultural adjustments should not be solely burdened by students (J. J. Lee & Rice, 2007). As research has shown acts of racism present on these campuses cannot all be attributed to students' cultural adjustment to the new environment (George Mwangi, Latafat, et al., 2018; J. J. Lee, 2017; J. J. Lee & Rice, 2007; Tierney, 1999). To some extent the

responsibility of adjusting the structural systems, in which racism has historically and currently thrives, is an institutional and societal responsibility. Institutional adjustments are essential to better support international students who more often than not have to navigate unwelcoming environments (George Mwangi, Changamire, et al., 2018; J. J. Lee & Rice, 2007).

This study contributes to the research on graduate education in three ways. First this study provides a quantitative look at international graduates' experiences in the U.S. Few studies include 12 public research universities where an even number of R1 and R2 institutions are represented. The contribution of this study is the use of data from a nationally administered graduate student survey that examines newly developed measures of intercultural relevancy in STEM (cultural integrity in STEM and connections with cultural representatives), identity prominence, and mentor interaction. The items and instruments of the graduate student experiences survey may be useful to other scholars and institutions. Intercultural relevancy in STEM and other measures of intercultural effort provide another way to interpret graduate student socialization. For improvements on international graduate students' socialization experiences in STEM to occur a review of current attitudes and perceptions towards those interactions at other American universities is critical.

Limitations

There are several limitations that need consideration when interpreting the findings of the study and dissemination to broader audiences. The first relates to the sample and the second survey design. Although the sample size of 953 was ample, the

numbers of men and women and disciplines were disproportionate. Alternatively, one could say that this characteristic makes the sample somewhat representative of STEM international graduate student population in the U.S. As a cross-sectional survey design, data issues arise from perceptions based on memory. We piloted the instrument twice, first with a small group of Native American graduate students and then at the four PNW-COSMOS campuses. Perhaps a more comprehensive design would have included participant interviews or a case study research prior to survey development and scale construction. The cultural congruity scale, mentor's cultural support, and peer interactions scales of the survey instrument were originally intended to measure the persistence of undergraduate students and in some cases for students of color (Pascarella & Terenzini, 1980). Having stated how the cultural congruity and integrity measures for PNW-COSMOS were pilot tested with a group of Native American students, it is unknown how the participants interpreted the questions. It may be that international participants' understanding of culture and the intention of the survey items is different from others who completed the survey. Unfortunately, with self-reported data those who responded to the survey may tend to be more engaged than those who declined the survey invitation (Creswell, 2009). Finally, I cannot draw conclusions about international graduate students' prior experiences, education, and international travel before coming to the U.S. to study. The length of time they have lived in the U.S., and the number of times they have traveled abroad is unknown. Time spent in the U.S. provides students with previous understanding of American norms, expectations, and attitudes, especially if they have travelled to the U.S. or other nations before attending graduate school. Those

students who are new to the U. S. may experience culture shock and acculturative stress due to lack of exposure (Boafo-Arthur, 2014; Mena et al., 1987; Smith & Khawaja, 2011) may place greater value on notions of intercultural relevancy.

A larger caveat is that the specific nation of origin and global regions were excluded from the survey. As participants' nation of origin is unknown, the choices for race/ethnicity on the survey may not reflect students' understandings of race (Weisberg, 2014). This variation of ethnicity within each racial group was present in the sample. This diversity and lack of nation of origin limits the generalizability of this study's finding to other populations. Further, the race/ethnicity categories differ from those used in other studies, including ones conducted by the National Science Foundation (National and the Center for Science and Engineering Statistics, 2013; Teranishi, 2007). Additionally, self-reported measures of race/ethnicity are American conceptions. Arab/Middle Easterner is included as a stand-alone category and Asian/Pacific Islander is classified in one category instead of two or even three distinctive racial categories, Native Hawaiian or Other Pacific Islander (Hawaiian, Guamanian, Chamorro, Samoan, or other Pacific Islander) and Asian (Asian Indian, Cambodian, Chinese, Japanese, Korean, Malaysian, Pakistani, Filipino, Thai, or Vietnamese). Lastly, this limitation is that there are important within race differences of international graduate students. These inner racial and ethnic differences were not captured in the GSE survey. Therefore, future studies should aim to explore these potential differences between different racial groups.

Implications for Research Methodology

There is a lack of quantitative instruments that measure social, cultural, and intercultural features of the graduate student experience. A concerted effort can be made by researchers and leaders of graduate studies to develop a research agenda around measures of intercultural effort and cultural learning. Intercultural constraints on the admission and graduate school success of international students are real, identifiable, and measurable (Dowd et al., 2011). Past calls for research on measures of intercultural efforts were made by higher education researchers of undergraduate education (Dowd et al., 2011; Myles & Cheng, 2003; Tanaka, 2007). Measures of intercultural effort are also needed at the graduate level (Tanaka, 2007). One example that this study relies on is the work of Museus and Maramba (2011) who adopted intercultural efforts and integrated the concepts of sense of belonging, cultural integrity, and cultural dissonance (Museus & Quaye, 2009) and other sources to research the impact of cultural integrity, connections to cultural identity, cultural adjustment and sense of belonging among Filipino American students (Dowd et al., 2011; Tanaka, 2007). Dowd (2011) also notes the inequity in measures available that account for cultural and social differentials. The same argument could be made at the graduate level, by significant findings of race and ethnicity indicate this study. We need more rigorous analysis to understand the differences in cultural integrity and connections with cultural representatives across racial groups at the graduate level.

Intercultural efforts and relevancy measures made malleable at the graduate level could be useful and timely. These critical terms are often context specific and definitions

easily misunderstood when generalized (Weisberg, 2014; Wolf-Wendel, Ward, & Kinzie, 2009). Dowd et al. (2011) also asserts that, “without adequate measures, invalid inferences may be made at the research, institutional, and policy levels, regarding “student effort” and/or institutional effectiveness.” (p. 37). More importantly, this misrepresentation of data may be even more damaging to vulnerable populations who invest and participate in graduate education in the U.S.

Posselt and Grodsky (2017) undertook a study that examined the stratification of graduate education in the United States. Though admittedly it excluded STEM, the implications are far reaching in terms of the economic impact of earning a graduate degree and the global benefits international students bring back to their home country. Alternately, if international graduates remain in the United States their intellectual contributions make the hiring and retention of international faculty desirable (Chien, 2013; Musumba, Jin, & Mjelde, 2011; Sá & Sabzalieva, 2018; Szelényi, 2006). Admissions and holistic review and the “great brain race” (Posselt, 2016; Sá & Sabzalieva, 2018) are two burgeoning areas of research that may increase our understanding of the complex investments made by students and the economic impacts in the U.S and abroad. The term “brain drain” was coined in the late sixties. The phenomena of “brain drain” is described by Musumba, Jin, and Mjelde (2011) as the “migration of skilled human capital, includes educated and trained persons who migrate from developing countries to join the workforce of developed countries and students who attend universities in developed countries but do not return home” (p. 501). To counter the dated “brain drain” concept a paradigm shift is needed. Especially as developing

nations have increased access to higher education. Perhaps the notion of “brain circulation” is more appropriate as access has increased and mobility patterns (Szelényi, 2006). Students have more choices in graduate schools around the world. For example, China’s rise in popularity among countries like Taiwan, Korea, and India reflect this shift in the needs of international students. Brain circulation is made possible with friendlier immigration and visa policies that allow for softer border crossings. While Canada is seeing fast pace growth in applications for graduate school from international students, the U.S. is experiencing swift declines in international applications. Federal visa and immigration policies in the U.S. are negatively impacting internationalization goals of American institutions. Current U.S. visa policies actually encourage student departure upon degree completion. Conversely, countries that have adopted friendlier visa and immigration policies, such as Canada and Australia, have seen a rise in higher education institutions ability to recruit and retain international talent.

Future Research Considerations

Based on my findings, I have two recommendations for future research. First, research can examine international STEM experts’ intercultural learning experiences from a life course perspective to understand organizational socialization. And second, research can examine structural systems and the relationship between identity salience and cultural representatives for international doctoral students. These two areas offer unique vantage points to gather insights into the formation of STEM experts and

transnational identity, and the surrounding systems of organizational socialization (Szelényi & Bresonis, 2014; Tierney, 1988, 1997).

The strength of the relationships between socialization and intercultural relevancy for international STEM experts can provide profound insights into essential features and pivotal points of career development. Intercultural learning and socialization may help to explain international STEM expert development from recruitment to graduate school through completion and into their career entry. First, social and cultural aspects of graduate student socialization are areas that could help us to understand how daily interaction inform one's self-concept and is changed through interaction with others as we change them. This reciprocal process of social interaction with faculty is transformative for graduate students. Especially important to note is how environments have the power to encourage intercultural learning in the advising mentoring relationship. Research can deconstruct critical understandings of power differentials that are diffused by intercultural learning. Further, how might this cultural exchange benefit cultural knowledge and research in a global world. Research that encourages participant-centeredness could contribute needed understanding about international students and cultural relevancy. Marginson (2013) asserts, "the idea of international education as self-formation, not another-directed adjustment, puts student centeredness into practice." (p. 9). Listening to the stories of international STEM experts may be less objective but more inclusive of specific groups.

The second area of research concerns the relationship between identity salience and connections with cultural representatives, which were found significant. Much is still

to be learned from identifying and describing the role of cultural agents and this is an important area to explore. Specifically, and yet to be determined is an understanding of who these cultural representatives are for international students and the ways supports are presented. We know from the literature that students often build a cultural community on American campuses (Myles & Cheng, 2003; Terrazas-Carrillo et al., 2015). Cultural representatives are the people from a similar culture who tend to connect with and validate an individuals' culture. During graduate school, studies have found cultural isolation contributes to acculturative stressors (Rice et al., 2009). At the graduate level much less is known about the influence of cultural agents, and this deficiency makes this line of inquiry worthy of qualitative examination to explore how cultural agents support identity formation (Gomes & Tran, 2017; Ward & Zarate, 2015). The identity prominence measure conveys the level of importance in that moment as opposed to a measure of identity salience which happens over time and measures multiple identities. Identity salience would need to be measured through a longitudinal or experimental design. This area needs further research to understand the influence of identity salience on cultural integrity and connections to culture representatives. For example, how do students tell their story of transnational identity? How does positive self-concept and professional identity inform students' perceptions of their value within a given STEM research environment?

The findings of this study can inform future inquiries on intercultural relevancy beyond graduate school. For example, life course perspectives (Gubrium & Holstein, 2000) could help illuminate and differentiate experiences at various phases over the

course of a career in STEM. The postdoctoral research position is an understudied yet more common career choice after the PhD. The role of global market trends in STEM and transitions to industry. Especially, the accompanying career expectations and attitude differentials towards work balance across disciplines and the role of culture.

Recommendations for Policy and Practice

A critical issue facing practitioner and policy communities today concerns the well-being, safety, and security of international graduate students who are currently studying in the United States. It is a multi-faceted yet straightforward problem relevant to present and future internationalization efforts and essential to improving the recruitment and well-being of international students. Understanding international graduate students' perceptions of their socialization experiences in STEM can help institutions implement healthier practices for international graduate students. This study's findings and the literature influenced the development of a framework to highlight practices support international graduate students at four levels: institution, college, department, and faculty. To encourage intercultural learning in graduate education, I present intercultural socialization practices for professionals and institutions. It is intended to help those who work to support the participation and well-being of international students at American public research universities. Professionals, graduate recruitment and influential communicators of the unique needs of international graduate students are especially important to reach. Professionals have the agency to communicate, train, and perhaps

implement program supports for faculty and graduate students centrally to make processes, and programs more visible.

The interculturally relevant socialization practices for professionals and institutions were influenced by the literature presented in Chapter Two (Manathunga, 2017; Todoran, 2018) and recent work from other professional associations, NAFSA and NAGAP (Johnson, 2018; J. J. Lee, 2017; Saubert, 2017, 2018). Current practices that exemplify intercultural relevancy in STEM, social interactions with mentor and peers, and identity prominence — are organized in Table 5 based on the findings of this study and the literature (Johnson, 2018; Todoran, 2018). Some example activities in the framework for a college or graduate school is to create an event that promotes a global and international perspective of STEM research. The event could ask students to translate their research to a general audience. Another practice for faculty is to connect incoming students with cultural supports on campus. Todoran (2018) highlights universities can foster self-efficacy by preparing international and domestic graduate students for a global job market. The framework can be used to incite discussion among students, faculty, leadership, and other stakeholders on the unique needs of international students who choose to attend American public research universities. A heuristic for institutions to identify their current internationalization strategies with aspirational practices to better support international graduate students.

Table 5.1. Intercultural socialization practices for professionals and institutions to support international graduate students

INTERCULTURAL SOCIALIZATION: APPLICABLE PRACTICES TO SUPPORT INTERNATIONAL STUDENTS
<i>INTERCULTURAL RELEVANCY IN STEM</i> Practice: Cultural integrity in STEM • Create an event that promotes a global and international perspective of STEM research. The event could ask students to translate their research to a global context e.g., colloquium series. (College, Graduate School) Practice: Connections with Cultural Representatives • Connect incoming students with cultural supports e.g., co-national and national community members. (Department, Faculty)
<i>SOCIAL INTERACTIONS</i> Practice: Mentor's Cultural Support • Acknowledge current issues international students face, i.e., financial insecurity and stress, travel uncertainty, and hostile political climate. (International Office, Faculty) • Connect students with professional supports for the job market in home country and the U.S. (Graduate School, Department, Faculty) Practice: Peer Interactions • Provide opportunities for social and cultural exchange, or outings to foster relationships among peers e.g., Lunch and learn academic writing, research, and statistics support. (College, Department)
<i>IDENTITY PROMINENCE</i> Practice: Social Identity • Help students acclimate to the community with practical amenities, e.g., airport shuttle, grocery and mall shopping shuttle bus on the weekend. (Faculty) Practice: Professional Identity • Foster self-efficacy in research communications for global audiences in home and host country, e.g., International and U.S. job market professional development workshops on the transferability of skills to careers. (Graduate School, Department)

Closing Remarks

Broader impacts of the research are evident in two notable areas: empirical research on international graduate students' socialization in STEM and its' unique contributions to the literature on graduate student socialization and intercultural studies. Given the complex nature of graduate school pathways, understanding international graduate students' experiences can provide us with more insight into the cultural and behavioral norms embedded in American graduate education. All graduate students go through varying degrees of anticipatory socialization to prepare them for their professional fields. Critics assert that graduate student socialization theory is too general and places much emphasis on the need for the "other" to assimilate and adopt the dominant group's knowledge, behaviors, attitudes, and values (Antony, 2002).

On understanding existing research on international students. This foundational review influenced the selection of constructs for study and the development of statistical models to test possible associations among these constructs for international graduate students. Testing possible associations between intercultural aspects of the socialization process were done to ensure the research was culturally responsive and empirically grounded. This research used a large-scale survey conducted at 12 American public research universities. The sample includes 1,085 international participants matriculated in NSF categorized STEM disciplines at varying points along the graduate degree continuum.

The second impact of the research is the unique contribution to the literature on graduate student socialization, intercultural studies, and empirical research on international graduate students experiences at American institutions. The intercultural

framework heuristic helped to prioritize and center cultural perspectives. These findings, when interpreted through the lens of an intercultural framework, illustrate that traditional modes of graduate student socialization may fall short for international students.

Traditional notions of socialization embrace an assimilative and apprenticeship typology.

The utility of socialization theory faces ongoing criticism for treating graduate student socialization process as the same for all students. The similarities in socialization are essential parts; however, these parts do not take the place of other ways of people may experience professionalization and change. As a theory, this idea neglects to capture the complexity of social interactions and the ways cultural learning shapes identity. It may also overlook the hidden costs international students pay both figurately and literally to gain entry to American Higher Education. Entry into the known in-group may require those less advantaged to adopt the ways, attitudes, values, skills, and behaviors of the dominant group to gain acceptance and entry in the next professional field as PhDs on the market.

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APPENDICES

APPENDIX A

NSF AND NIH DISCLAIMERS

National Science Foundation (NSF) Disclaimer

The primary sponsor for PNW-COSMOS is the National Science Foundation (NSF), Directorate for Education and Human Resources (EHR), Division of Human Resource Development (HRD). This project is supported by: Collaborative Research: The Pacific Northwest Alliance to develop, implement and study a STEM Graduate Education Model for American Indians and Native Alaskans. This is an AGEP - T: Alliances for Graduate Education and the Professoriate – Transformation under HRD grants # 1432932 (Washington State University), #1432910 (University of Idaho), #1432694 (University of Montana), and #1431773 (Montana State University). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

National Institutes of Health (NIH) Disclaimer

Research reported in this publication was also supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award Number P20GM103474. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

APPENDIX B

THE PACIFIC NORTHWEST CIRCLE OF SUCCESS: MENTORING
OPPORTUNITIES IN STEM AWARD ABSTRACT #143291

The Pacific Northwest Circle of Success:
Mentoring Opportunities in STEM (PNW-COSMOS)
National Science Foundation, Directorate for Education and Human Resources (EHR),
Division of Human Resource Development

Award Abstract #1432910

Collaborative Research: The Pacific Northwest Alliance to Develop, Implement and Study a STEM Graduate Education Model for American Indians and Native Alaskans

ABSTRACT

Washington State University, the University of Montana, the University of Idaho and Montana State University are collaborating to create the Pacific Northwest Alliance: Collaborative Opportunities for Success in Mentoring of Students (PNW-COSMOS). These alliance schools also partner with Salish Kootenai College, Montana Tech of the University of Montana, Northwest Indian College and Heritage University. This project was created in response to the NSF's Alliances for Graduate Education and the Professoriate (AGEP) program solicitation (NSF 14-505) for the AGEP-Transformation (AGEP-T) track. The AGEP-T track targets strategic alliances of institutions and organizations to develop, implement, and study innovative evidence-based models and standards for STEM graduate education, postdoctoral training, and academic STEM career preparation that eliminate or mitigate negative factors and promote positive practices for URMs.

The goal of the Pacific Northwest AGEP-T Alliance is to increase the number of American Indian/Alaska Native (AI/AN) students who complete STEM graduate programs with specific emphasis on doctoral degrees, by developing, implementing and studying a model of culturally congruent STEM graduate education and academic STEM career preparation. This project is contributing to foundational knowledge about the recruitment, retention and graduation of AI/AN graduate students in STEM. The emphasis on culturally-relevant and culturally-immersive activities is a unique intervention approach for graduate students and their mentoring faculty in STEM. PNW-COSMOS has the potential to provide results that may transform the way the field engages and works with URM graduate students in rural environments and in regions of the country where there are AI/AN in STEM. The lessons learned as this project progresses, and the ultimate results from the work, will provide information that will be beneficial to educators, administrators and policymakers, as well as the general public.

The Social Science Research Project (SSRP) of PNW-COSMOS seeks to understand what influences graduate student success in STEM disciplines. In particular, the SSRP activities examine how socialization is facilitated by culturally congruent approaches to student-faculty mentorship. Consistent with the overall goal of the PNW-COSMOS project to

improve retention and graduation rates for American Indian/Alaska Native (AI/AN) graduate students in STEM programs, the SSRP focuses on cultural congruity for students from different cultural and ethnic groups including students from AI/AN backgrounds and other underrepresented minority groups as a means to look at essential components of cultural congruity and mentoring.

Outcomes from the SSRP activities will determine if and how cultural congruity contributes to effective mentoring and socialization. Such knowledge informs the objectives of the PNW-COSMOS grant to develop, implement, and assess effective models of AI/AN graduate student recruitment and retention. The addendum builds on the ideas and theoretical constructs in the original proposal and is focused on the following research questions, activities, methodologies, and timelines to carry out the SSRP.

APPENDIX C

PNW-COSMOS GRADUATE STUDENT EXPERIENCES SURVEY

AGEP Survey

Q1 As a person who is pursuing a graduate degree in a Science, Technology, Engineering, and Mathematics (STEM) program, you are among the highest achieving students in universities across the country. In an effort to inform existing knowledge and practice, you are invited to participate in this online survey that is a part of a National Science Foundation (NSF) Alliances for Graduate Education and Professoriate (AGEP) sponsored research project (HRD's-1432694, 1432910, 1431773, 1432932). Attitudes towards and strategies for educational success among students in STEM graduate programs in the United States is a primary focus of the survey. It also examines how culture and ethnicity impact student learning and success outcomes at the graduate level. Questions on the survey are organized in to three sections. It is anticipated that the survey will take approximately 30 minutes to complete. Participation is voluntary and responses will be kept confidential to the degree permitted by the technology being used. Submission of the survey will be interpreted as your informed consent to participate and affirmation that you are at least 18 years of age. No personally identifiable information will be used in any reporting of the information that you provide. Any reporting of the data gathered will be done in a summary format to protect the privacy of participants. The results from the research will be shared with the NSF. Summary findings from the survey may appear on the NSF webpage and shared with current and/or pending AGEP award recipients. Summary findings will be used in research papers and reports that are intended to inform the educational, researcher, and practitioner audiences to better understand the factors that influence attitudes towards and strategies used by students in STEM programs. If you have any questions about the research, please contact Principal Investigator, Dusten Hollist, Ph.D. via email at dusten.hollist@mso.umt.edu or via telephone at (406)-243-2843. Please print or save a copy of this page for your records. Page can be printed or saved by right clicking on the mouse and then choose "print" or "save as." As your progress through the survey, you may need to scroll down occasionally in order to proceed to the next screen. You can use your mouse, down arrows, or the slide bar to the right of your screen to scroll down. Click on the red box with white arrows found in the bottom right of the white box to move to the next screen throughout the survey.

- ☐ Yes, I have read/been read the above information and would like to participate in the research (1)
- ☐ No, I do not wish to participate in the research (2)

If No, I do not wish to partic... Is Selected, Then Skip To End of Survey

Q2 Section One: Background The questions in this section ask you to provide some background information about yourself.

Q3 What department are you currently a student in? (Please list department name in the space below).

Q4 What is your ethnicity?

- ☐ Arab/ Middle Eastern (1)
- ☐ Asian/ Pacific Islander (2)
- ☐ Black/ African American (3)
- ☐ Hispanic/Latino (5)
- ☐ American Indian/ Alaska Native (7)
- ☐ White/ Caucasian (8)
- ☐ Other (Please list in box below) (9) _____

Q5 Which of the following is the degree type you are currently pursuing?

- ☐ Master's (1)
- ☐ Doctoral (2)

Answer If Which of the following is the degree type you are currently pursuing? Master's Is Selected

Q6 Which of the following academic milestones have you completed towards your Master's degree? Check all that apply.

- ☐ Thesis Committee chosen (1)
- ☐ Thesis proposal successfully completed (2)
- ☐ Thesis completed and approved by committee (3)
- ☐ Thesis defended successfully and approved by committee (4)
- ☐ Thesis submitted to the Graduate School (5)

Answer If Which of the following is the degree type you are currently pursuing? Doctoral Is Selected

Q7 Which of the following academic milestones have you completed towards your PhD? Check all that apply.

- ☐ Coursework completed (2)
- ☐ Committee chosen (1)
- ☐ Completion of oral/written comprehensive exams (3)
- ☐ Dissertation proposal completed and approved (4)
- ☐ Dissertation completed and approved by committee (6)
- ☐ Dissertation successfully defended and approved by committee (7)
- ☐ Dissertation submitted to the Graduate School (5)

Q8 What year are you in your current program of study?

- ☐ 1st year student (1)
- ☐ 2nd year student (2)
- ☐ 3rd year student (3)
- ☐ 4th year student (4)
- ☐ 5th year student (5)
- ☐ more than 5 years in program (6)

Q9 Have you ever taken a semester or more break from school while pursuing your current degree?

- ☐ Yes (1)
- ☐ No (2)

Answer If Have you ever taken a semester or more break from school while pursuing your current degree? Yes Is Selected

Q10 Have you taken more than one break from pursuing your current degree?

- ☐ Yes (1)
- ☐ No (2)

Answer If Have you ever taken a semester or more break from school while pursuing your current degree? Yes Is Selected

Q11 Including all breaks, how many semesters total have you taken off from pursuing your current degree? (Please enter in a numerical value, like 1 for one semester total, 2 for two semesters total, and so on).

Q13 What is your PARENT(S) highest level of education? Please specify if Parent-1 is your mother or father, and if Parent-2 is your mother or father by typing your choices in the spaces provided below.

[illegible]

Q14 Please check all that apply to you.

- ☐ I am the first person in my family to attend college. (1)
- ☐ I am the first person in my family to graduate from college. (2)
- ☐ I am the first person in my family to seek a STEM degree. (3)

Q15 Where do you plan on putting your degree into practice?

- Close to where I am from. (1)
- Away from where I am from. (2)
- Wherever I can get hired. (3)

Q16 How far is the University where you are currently attending from the place where you grew up?

- ☐ I am studying in the same town/city that I am from. (1)
- ☐ I am studying within 50 miles from the town/city that I am from. (2)
- ☐ I am studying within 100 miles from the town/city that I am from. (3)
- ☐ I am studying more than 100 miles but less than 500 miles from the town/city that I am from. (4)
- ☐ I am studying more than 500 miles from the town/city that I am from. (5)

Q17 Section Two: Graduate School Experiences This section asks questions about your experiences at the University you are currently attending and your interactions with faculty, staff, and students.

Q18 How often have you utilized the resources listed below at the University you are currently attending?

[illegible]

Q19 For each of the following items, indicate the extent to which you have experienced the feeling or situation at the university you are currently attending.

[illegible]

Q20 Please indicate to what extent you agree that the following statements about faculty/staff at the university you currently attend are true.

[illegible]

Q21 Please indicate to what extent you agree that the following statements about the university you currently attend are true.

[illegible]

Q22 Please indicate to what extent you agree or disagree with the following statements about your personal development while attending your current university.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree nor Agree (3)	Agree (4)	Strongly Agree (5)
Since coming to this university I have developed close personal relationships with other students. (1)	☐	☐	☐	☐	☐
The student friendships I have developed at this university have been personally satisfying. (2)	☐	☐	☐	☐	☐
My interpersonal relationships with other students have had a positive influence on my personal growth, attitudes, and values. (3)	☐	☐	☐	☐	☐
My interpersonal relationships with other students have had a positive influence on my intellectual growth and interests in ideas. (4)	☐	☐	☐	☐	☐
It has been difficult for me to meet and make friends with other students. (5)	☐	☐	☐	☐	☐
Students would be willing to listen to me and help if I had personal problems. (6)	☐	☐	☐	☐	☐
I am more likely to attend a cultural event (for example, a concert, lecture, or art show) now than I was before coming to this university. (23)	☐	☐	☐	☐	☐

Q23 Please indicate to what extent you agree or disagree with the following statements about classroom interactions with the faculty that you have interacted with while attending your current university.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
My classroom interactions with faculty have had a positive influence on my personal growth, values, and attitudes. (1)	☐	☐	☐	☐	☐
The faculty members I have contact with are generally interested in students. (3)	☐	☐	☐	☐	☐
The faculty members I have had contact with are generally outstanding or superior teachers. (4)	☐	☐	☐	☐	☐
The faculty members I have had contact with are genuinely interested in teaching. (5)	☐	☐	☐	☐	☐

Q24 Please indicate to what extent you agree or disagree with the following statements about non-classroom interactions with the faculty that you have interacted with while attending your current university/college.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
My non-classroom interactions with faculty have had a positive influence on my personal growth, values, and attitudes. (1)	☐	☐	☐	☐	☐
My non-classroom interactions with faculty have had a positive influence on my career goals and aspirations. (2)	☐	☐	☐	☐	☐
Since coming to this university I have developed a close personal relationship with at least one faculty member. (3)	☐	☐	☐	☐	☐
I am satisfied with the opportunities to meet/interact informally with faculty. (4)	☐	☐	☐	☐	☐
The faculty members I have had contact with are willing to spend time out of class to discuss issues of interest and importance to students. (6)	☐	☐	☐	☐	☐
The faculty I have had contact with are interested in helping students grow in more than just academic areas. (7)	☐	☐	☐	☐	☐

Q25 Please indicate to what extent you agree or disagree with the following statements about your academic and intellectual experiences while attending your current university/college.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
I am satisfied with the extent of my intellectual development since enrolling in the university. (1)	☐	☐	☐	☐	☐
I am satisfied with my academic experiences at this university. (2)	☐	☐	☐	☐	☐
My courses this year have been intellectually stimulating. (4)	☐	☐	☐	☐	☐
My academic experience has had a positive influence on my intellectual growth and interests in ideas. (5)	☐	☐	☐	☐	☐
I have performed academically as well as I anticipated I would. (7)	☐	☐	☐	☐	☐

Q26 Do you regularly seek guidance from your major professor/committee chair?

- ☐ Yes (1)
☐ No (2)

Q27 Please indicate to what extent you agree or disagree with the following statements about your major professor/committee chair.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
Is regularly available for advising. (1)	☐	☐	☐	☐	☐
Meets with me to discuss research. (2)	☐	☐	☐	☐	☐
Is interested in my goals and projects. (3)	☐	☐	☐	☐	☐
Provides constructive criticism on my project/research. (4)	☐	☐	☐	☐	☐
Returns my work in a timely manner. (5)	☐	☐	☐	☐	☐

Q28 Please indicate to what extent you agree or disagree with the following statements about your major professor/committee chair.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
Is interested (engaged) in my culture. (1)	☐	☐	☐	☐	☐
Is interested in me beyond my academic role (what I can contribute academically). (2)	☐	☐	☐	☐	☐
Is tolerant about any cultural differences between us. (3)	☐	☐	☐	☐	☐
Appreciates cultural diversity. (4)	☐	☐	☐	☐	☐
Is friendly toward my family. (5)	☐	☐	☐	☐	☐

Q29 Please indicate to what extent you agree or disagree with the following statements about your academic and intellectual experiences while attending your current university/college.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
It is important for me to graduate from college. (2)	☐	☐	☐	☐	☐
I am confident that I made the right decision in choosing to attend this university. (3)	☐	☐	☐	☐	☐
It is likely that I will register at this university next term. (4)	☐	☐	☐	☐	☐
It is not important to me to graduate from this university. (5)	☐	☐	☐	☐	☐
Getting good grades is not important to me. (7)	☐	☐	☐	☐	☐

Q30 To what extent do you agree or disagree with the following statements about your STEM graduate student experiences in your current program.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
My experiences in STEM are shaped by my cultural meaning systems. (1)	☐	☐	☐	☐	☐
I have a strong cultural identity that guides the meanings that I attach to my interest in STEM. (2)	☐	☐	☐	☐	☐
It is important for me to see how my culture of origin aligns with the STEM environment. (3)	☐	☐	☐	☐	☐
I experience very few cultural conflicts with my STEM education. (4)	☐	☐	☐	☐	☐

Q31 To what extent do you agree or disagree with the following statements about STEM graduate student experiences. Depending on your computer, you might need to scroll down with your mouse or arrow keys in order to proceed to the next screen. Note the following definitions: *Cultural conflict is a term used to describe conflict that occurs because of differences in cultural beliefs and values. *Cultural representatives are people who identify with the same culture and share the same beliefs and customs. *Persistence is the quality of a person that allows them to attempt or continue a difficult task despite opposition and/or resistance.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree or Agree (3)	Agree (4)	Strongly Agree (5)
Graduate students who experience cultural conflict must adjust to the dominant culture on campus, or have good connections at their university with cultural representatives to be persistent. (1)	☐	☐	☐	☐	☐
The extent that individuals appreciate a graduate student's culture of origin can reduce the amount of cultural conflict experienced by the student, which can increase the student's persistence. (2)	☐	☐	☐	☐	☐
The quality and quantity of a graduate student's connections with various cultural representatives on their own campuses is positively associated with their likelihood of persistence. (3)	☐	☐	☐	☐	☐
Graduate students are more likely to persist if cultural representatives emphasize educational achievement, educational attainment, value, and cultural heritage. (4)	☐	☐	☐	☐	☐

Q32 Section Three: This final section asks you to respond to a series of demographic questions. The answers to these questions will be used to examine similarities and differences in graduate school experience by age, gender, and marital status of participants. Click on the red box with the white arrows toward the bottom right of the screen to continue.

Q33 What is your present citizenship status?

- ☐ U.S. Citizen (1)
- ☐ Naturalized U.S. Citizen (2)
- ☐ U.S. Permanent Resident (green card holder) (3)
- ☐ Dual Citizen-U.S. Permanent resident (green card holder) and citizen of another country (4)
- ☐ Citizen of another country, residing in the U.S. with a student visa or other nonresident visa (5)

Q34 What is your current age?

- ☐ 18-21 years old (1)
- ☐ 22-24 years old (2)
- ☐ 25-30 years old (3)
- ☐ 31-35 years old (4)
- ☐ 36-40 years old (5)
- ☐ 41-50 years old (6)
- ☐ 51-60 years old (7)
- ☐ 60 or more years old (8)

Q35 What is your gender?

- ☐ Male (1)
- ☐ Female (2)
- ☐ other (3)

Q36 What is your marital status?

- ☐ Single, never married (1)
- ☐ Married/ domestic partnership (2)
- ☐ Widowed (3)
- ☐ Divorced (4)
- ☐ Separated (5)

Q37 How many dependents do you have?

- ☐ None (1)
- ☐ One (2)
- ☐ Two (3)
- ☐ Three (4)
- ☐ Four (5)
- ☐ Five (6)
- ☐ More than five (7)

Q38 Thank you for participating in the survey. Your answers will provide valuable information that will be used to inform national discussion about STEM education. In the space below, please provide any insights, questions, or comments about the survey that you feel are important.

APPENDIX D

NSF STEM CLASSIFICATION BY BIGLAN'S FOUR
DISCIPLINARY TYPOLOGIES

**National Science Foundation STEM Classification of Instructional Programs (CIP Code)
by Biglan's Four Disciplinary Typologies**

Agricultural Sciences		14.0799	Chemical Engineering, Other.
		14.1003	Laser and Optical Engineering.
01.09	Animal Sciences	14.1004	Telecommunications Engineering.
01.10	Food Science and Technology	14.1099	Electrical, Electronics and Communications Engineering, Other.
01.12	Soil Sciences		
01.99	Agriculture, Agriculture Operations and Related Sciences, Other	14.32	Polymer/Plastics Engineering
		14.4	Paper Science and Engineering.
03.0101	Natural Resources/Conservation, General	14.41	Electromechanical Engineering.
03.02	Natural Resources Management and Policy	14.42	Mechatronics, Robotics, and Automation Engineering.
03.03	Fishing and Fisheries Sciences and Management	14.43	Biochemical Engineering.
03.05	Forestry	14.44	Engineering Chemistry.
03.06	Wildlife and Wildlands Science and Management	14.45	Biological/Biosystems Engineering.
03.99	Natural Resources and Conservation, Other	15.0306	Integrated Circuit Design.
Chemistry		15.1502	Engineering Design.
		15.16	Nanotechnology.
		04.02	Architecture
		14.04	Architectural Engineering
40.05	Chemistry	14.08	Civil Engineering
40.0507	Polymer Chemistry	14.0803	Structural Engineering
40.0509	Environmental Chemistry.	14.0805	Water Resources Engineering
40.051	Forensic Chemistry.	14.14	Environmental/Environmental Health Engineering
40.0511	Theoretical Chemistry.		
40.1002	Materials Chemistry.	14.09	Computer Engineering, General
40.1099	Materials Sciences, Other.	14.10	Electrical, Electronics and Communications Engineering
Computer Science		14.12	Engineering Physics
		14.13	Engineering Science
11.01	Computer and Information Sciences, General	14.27	Systems Engineering
		30.06	Systems Science and Theory
11.0104	Informatics (STEM Only)	14.11	Engineering Mechanics
11.04	Information Science/Studies	14.19	Mechanical Engineering
11.07	Computer Science	14.06	Ceramic Sciences and Engineering
52.1201	Management Information Systems, General	40.18	Materials Engineering
52.1301	Management Science	14.20	Metallurgical Engineering
		14.28	Textile Sciences and Engineering
Engineering		40.10	Materials Science
		14.21	Mining and Mineral Engineering
14.02	Aerospace, Aeronautical and Astronautical Engineering	14.23	Nuclear Engineering
14.03	Agricultural Engineering	14.25	Petroleum Engineering
14.05	Biomedical/Medical Engineering	14.01	Engineering, General
03.0509	Wood Science and Wood Products/Pulp and Paper Technology	14.22	Naval Architecture and Marine Engineering
		14.24	Ocean Engineering
14.07	Chemical Engineering	14.99	Engineering, Other
14.0702	Chemical and Biomolecular Engineering.		

Environmental Science

- 03.0103 Environmental Studies
- 03.0104 Environmental Science

Geosciences

- 40.06 Geological and Earth Sciences/Geosciences
- 40.0601 Geology/Earth Science, General

Life/Biological Sciences

- 26.0403 Anatomy
- 26.0202 Biochemistry
- 26.01 Biology, General
- 26.1101 Biometry/ Biometrics
- 26.1102 Biostatistics
- 26.1309 Epidemiology
- 26.0203 Biophysics
- 26.03 Botany/Plant Biology
- 26.0305 Plant Pathology/Phytopathology
- 26.0307 Plant Physiology
- 26.04 Cell/Cellular Biology and Anatomical Sciences
- 26.0401 Cell/Cellular Biology and Histology
- 26.0204 Molecular Biology
- 26.1301 Ecology
- 26.0505 Parasitology
- 26.0702 Entomology
- 26.0801 Genetics, General. (NEW)
- 26.0804 Animal Genetics. (NEW)
- 26.0805 Plant Genetics. (NEW)
- 26.1303 Evolutionary Biology
- 26.0806 Human/Medical Genetics
- 26.0508 Microbiology and Immunology.
- 26.0807 Genome Sciences/Genomics.
- 26.05 Microbiological Sciences and Immunology
- 26.0507 Immunology
- 26.0504 Virology
- 26.0503 Medical Microbiology and Bacteriology
- 26.1501 Neuroscience

- 19.05 Foods, Nutrition, and Related Services
- 30.1901 Nutritional Sciences
- 26.0910 Pathology/Experimental Pathology
- 26.1001 Pharmacology
- 26.1004 Toxicology
- 26.1104 Computational Biology.
- 26.131 Ecology and Evolutionary Biology.
- 26.0707 Animal Physiology. (NEW)
- 26.0901 Physiology, General. (NEW)
- 26.09 Physiology, Pathology and Related Sciences
- 26.07 Zoology/Animal Biology
- 26.1201 Biotechnology
- 26.1302 Marine Biology and Biological Oceanography
- 26.99 Biological and Biomedical Sciences, Other
- 30.01 Biological and Physical Sciences
- 30.10 Biopsychology
- 30.27 Human Biology.
- 30.3 Computational Science.
- 30.32 Marine Sciences.

Mathematics

- 27.01 Mathematics
- 27.03 Applied Mathematics
- 27.0304 Computational and Applied Mathematics.
- 27.0306 Mathematical Biology.
- 27.0503 Mathematics and Statistics.
- 14.3701 Operations Research
- 27.99 Mathematics and Statistics, Other
- 30.08 Mathematics and Computer Science
- 27.05 Statistics
- 52.1304 Actuarial Science

Physics/Astronomy

- 40.02 Astronomy and Astrophysics
- 40.0809 Acoustics
- 40.08 Physics
- 40.0607 Oceanography, Chemical and Physical
- 40.0807 Optics/Optical Sciences
- 40.9999 Physical Sciences, Other

Note: CIP Code categories is based on the National Science Foundation approved STEM programs and chart from LSAMP, OMB #3145-0226, April 30, 2019

STEM Fields by Biglan's Four Disciplinary Typologies	NSF STEM Classifications
<i>PURE-LIFE-HARD</i> Biology (general) Biochemistry or biophysics botany Environmental science Microbiology or bacteriology zoology Kinesiology	LIFE/BIOLOGICAL SCIENCES ENVIRONMENTAL SCIENCE
<i>PURE-NON-LIFE</i> Astronomy Atmospheric science (incl. Meteorology) chemistry Earth science (incl. Geology) Mathematics Physics Statistics	CHEMISTRY GEOSCIENCES MATHEMATICAL SCIENCES PHYSICS AND ASTRONOMY
<i>APPLIED-LIFE</i> Medicine Dentistry Veterinarian Pharmacy Agriculture Speech	AGRICULTURAL SCIENCES
<i>APPLIED-NON-LIFE</i> Aero-/astronautical engineering Civil engineering Chemical engineering Electrical or electronic engineering Industrial engineering Materials engineering Mechanical engineering General/other engineering	COMPUTER AND INFORMATION SCIENCE AND ENGINEERING (CISE) ENGINEERING MATERIALS RESEARCH

Note: Categorization based on Biglan (1973a,b), Malaney (1986), and Stoecker (1993)
Source: Nelson Laird, Shoup, Kuh & Schwarz (2008)

APPENDIX E

CORRELATION MATRICES OF STUDY VARIABLES

Correlation matrices of the outcome variable are shown in the table below. The correlation matrix indicates that the outcome variables were distinctive though each one does fall under the construct of intercultural relevancy in STEM. Although, cultural integrity in STEM and connections with cultural representatives were found to be significantly correlated, $r = .250, p < .05$. However, because a threshold of .60 was not met it is not considered highly correlated (Fields, 2009). A correlation matrix was also created to evaluate associations among explanatory variables in the second table below. Mentors' academic support and mentors' cultural support were also found to be significantly correlated, $r = .67, p < .001$, and exceeds the threshold of .60 (Fields, 2009). The other two variables social and professional identity were not found highly correlated, $r = .41, p < .001$. Other tests for multicollinearity indicated that a very low level of multicollinearity was present among all the variables (VIF = 2.03 for mentors' academic support and 1.84 for mentors' cultural support).

Correlation Matrix for Key Measures/Outcome Variables (n = 953)

Outcome Variables	1	2
1. Cultural integrity in STEM	1.000	
2. Connections with cultural representatives	0.250*	1.00

Note: * $p < .05$. ** $p < .01$. *** $p < .001$.

Correlation Matrix for Key Measures/Explanatory Variables (n = 953)

Measure	1	2	3	4	5	6
1. Mentors' academic support	1.000					
2. Mentors' cultural support	0.668***	1.000				
3. Peer interactions	0.296***	0.365*	1.000			
4. Cultural congruity	0.299***	0.281	0.473	1.000		
5. Social identity	0.035*	0.093*	0.131*	0.346	1.000	
6. Professional identity	0.123***	0.136*	0.169*	0.112	0.4101	1.000

* shows significance at the .01 level

Note: * $p < .05$. ** $p < .01$. *** $p < .001$.