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Support from Institutional Agents and Perceptions of Cultural and Institutional Fit Among STEM International Graduate Students in the U.S.

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ABSTRACT

This quantitative study aimed to understand the association between different types of support from institutional agents and students' sense of belonging culturally and structurally at their respective institutions. We used one-of-a-kind primary survey data from a National Science Foundation grant that included nearly 1,000 international graduate students in STEM fields across 12 research institutions in the U.S. Drawing from the theories of cultural synergy and reciprocal adaptation, we proposed that support from all three institutional agents of peers, faculty, and mentors would be important for perceptions of fit but that the cultural aspects of mentor support would emerge as most important. Based on regression findings, we found that all three agents played a positive and statistical role in perceptions of cultural and structural fit. However, the results suggested that peer support played the largest role in promoting better perceptions of a sense of belonging culturally and institutionally.
Keywords: Culture, graduate studies, interpersonal relationships, STEM, student experience

The academic presence of international graduate students (IGS) in science, technology, engineering, and mathematics (STEM) departments are vital to U.S.

higher education institutions in two meaningful ways. First, they comprise a significant component of total enrollment in STEM programs. Second, this enrollment has tangible benefits for departments and institutions. For these reasons, it befits institutions to identify contexts that best support STEM IGS personally and academically so institutions can continue to benefit positively. The National Academies of Sciences, Engineering, and Medicine (NAS, 2018) identified these contexts for STEM IGS success, such as mentoring, advising, and institutional climate. To this end, we used primary survey data on nearly 1,000 STEM IGS at predominately-White institutions (PWIs) to examine how micro face-to-face interactions with supportive institutional agents (peers, mentors, faculty) influenced IGS' perceptions of their macro-institutional cultural fit and belonging. Our study filled several research gaps. To the best of our knowledge, our survey data on and sample size of STEM IGS and the statistical testing of peer, mentor, and faculty influences were the first of its kind in the field. Then, our focus on culture and social dynamics comprised an under researched agenda given that a recent review of publications on STEM from 2000 to 2018 found that only 9.8% of published articles addressed "culture, social, and gender" issues in STEM (Li et al., 2020).

BACKGROUND

STEM IGS enrollment size is vital to departments. The total enrollment of international graduate students (IGS) in the 2020/21 academic year (AY) was 329,272 (IIE, 2022). In 2019, IGS represented 37% of all graduate students and 41% of all doctoral students in Science and Engineering fields in 2019 and earned the second-largest percentage of STEM doctorate degrees at 37.5% and over 60% in certain STEM fields such as Civil and Mechanical Engineering and Computer and Information Sciences (NSF, 2021).

These robust enrollment figures result in tangible benefits to departments and institutions. Anderson (2014) argued that most doctoral institutions rely on IGS to maintain their graduate programs because IGS often constitute most students within specific fields that in turn attract top-flight faculty. Further, Regets (2007) used and found that an extra 10 IGS was associated with an extra 3.0 domestic White and 0.20 underrepresented minority students. Shih (2017) also found no crowding-out of domestic students by using IGS with the Integrated Postsecondary Education Data. For every 10 additional IGS there were 8 additional domestic graduate students. The positive benefits of IGS were due to high tuition revenue from IGS offsetting the cost of enrolling additional domestic students. NFAP (2021) concurred arguing the presence of IGS allows U.S. institutions to offer high quality STEM programs and without their presence the number of domestic students pursuing graduate degrees would pale in comparison to the U.S. economy. This report also cited the work of Chellaraj et al. (2008) that found for every 1,000 IGS blocked from graduate programs there was an estimated loss of $210 billion in university-based patents and $1 billion in lost tuition over a 10-year span.

Departments with a larger percentage of IGS also have higher rates of general graduation and graduation among domestic students. Abegaz et al. (2020) found that a 1% increase in IGS enrollment led to a 0.7% - 1.0% increase in graduation rates in California and Illinois. The study also found that for each additional IGS PhD recipient, the number of total graduates increased by about 0.7 and domestic graduates by 0.2. The graduation premium associated with IGS is critical for departments and institutions given that domestic students' graduation rates are 13-percentage points lower than their IGS peers in STEM fields (Council of Graduate Schools, 2008).

The findings above suggest that institutions have a vested interest in understanding how to best support IGS within STEM and U.S. universities. Yet Veliz (2020, p. 150) recently argued that among IGS in the U.S. "few studies have focused on their experiences connecting with and navigating the university community" especially those involving socializing agents and experiences. Han et al. (2015) stated that international students need these support structures in place to overcome cultural, language, and institutional issues—issues that are usually not faced by the general population or even domestic underrepresented minorities in STEM. Some of these processes may be mitigated as international students experience intercultural exchanges with institutional agents that support cultural transitions (Sullivan & Kashubeck-West, 2015).

We focused on macro-cultures of institutions as research showed that perceptions of cultural congruity and fit resulted in feelings of "belonging," or of sense of connection with others for students not members of the dominant culture (Gloria et al., 2016). An email survey of 1,535 domestic and 787 STEM IGS at 10 U.S. institutions with the largest IGS enrollments found that the most cited challenges were "cultural challenges" and "social challenges" by 63% and 59% of the sample, respectively (Han & Applebaum, 2016). We focused on supportive institutional agents as research has found that these agents facilitate structural and collaborative processes that help IGS in their academic and cultural transitions, especially within STEM fields (Veliz, 2020). These institutional agents may be part of the landscape that assists IGS in benefitting their departments and institutions.

CONCEPTUAL APPROACH & LITERATURE SUPPORT

Our study tapped macro contexts with two indices that measured the IGS' perceptions that (a) their culture aligned with culture of the institution (9-items), and (b) how comfortable and belong they felt on campus (7-items). The micro interactions included (a) peer interactions (7-items), (b) mentor cultural support (5-items), and (c) faculty support (6-items). Our study was informed by the complementary frameworks of Cultural Synergy (Cortazzi & Jin, 1997) and Reciprocal Adaptation (Zhou et al., 2008).

Cultural Synergy, Reciprocal Adaptation, and Intercultural Transitions

The concepts of *cultural synergy* and *reciprocal adaptation* suggest that interactions with peers, mentors, and faculty include positive and mutual intercultural exchanges to better facilitate intercultural transitions and a sense of belonging. Yet research has shown that even basic interpersonal and supportive interactions absent of cultural elements were beneficial, which supported arguments by Veliz (2020) that STEM IGS fared better when institutional agents were involved in the general socialization process.

Among 188 IGS at a large Midwestern research university, Curtin et al. (2013, p.129) found that greater levels of general support by their mentor/advisor was associated with a greater sense of belonging within the department largely through facilitating a sense of "fitting in." Lin and Schertz (2014) interviewed five IGS at a medium-sized rural university who reported that their basic social and academic interactions helped them to blend their origin cultures with the new cultures on campus. Rivas et al. (2019, p. 696) interviewed 17 undergraduate and graduate IS at a mid-size public university and found that basic and daily interactions helped them "learn to embrace the differences of classmates and of mainstream culture." Using data on IS from the 2014 Community College Survey of Student Engagement, Garcia et al. (2019) found that higher levels of academic, socio-academic, and social integration with institutional agents—peers and advisors but mostly faculty—all increased a sense of belonging on campus. Only one of the nine statistically significant integration measures tapped cultural factors. In a study of five IGS in a mid-size Canadian university, Moores and Popaduik (2011) analyzed 134 critical incidents and concluded that the narratives revealed that simple interactions and discussions with peers made the IGS feel like they were in a supportive family-like environment that valued them personally. Support from faculty and staff was not culturally specific but more about genuine academic and personal support ("caring") as well as practical and administrative aid, all of which helped the IGS transition cross-culturally. Lastly, Sullivan and Kashubeck-West (2015) surveyed 104 undergraduate and graduate IS and found that higher levels of a broad index of social support was associated with less acculturative stress.

These studies demonstrated that basic support from institutional agents was important for transcultural transitions and sense of belonging. Cultural synergy and reciprocal adaptation posit that support that includes cultural elements may best assist IGS in these processes. These concepts propose bi-directional socialization processes (Winkle-Wagner et al., 2020) that includes an egalitarian and developmental approach to transcultural transitions. This socialization process empowers individuals to access new skills and knowledge by building reciprocal connections with institutional agents that assist them in navigating an unfamiliar environment without the loss of their cultural heritage (Antony & Schaps, 2021).

Cortazzi and Jin (1997) suggested that international students experience different expectations and assumptions about relationships with their peers, mentors, and instructors based on differing cultural norms. To bridge these differences, "cultural synergy" highlights the benefits of positive intercultural exchanges between students and these influential agents. Zhou et al. (2008)

expanded the notion of cultural synergy to include "pedagogical adaptation" as the process whereby students and faculty recognize, understand, and adjust to diverse cultural learning and teaching approaches. Part of this framework highlighted the broader concept of "reciprocal adaptation" that emphasized that all parties are responsible for cultural understanding, learning, and support, development of new skills, and adapting practices to successfully navigate the educational context. Both concepts assumed that agents and international students may have different assumptions and expectations about the cultural, academic, and learning environments. To enable the process of cultural transitions, it is important for cross-cultural learning to occur through interactions with and support from their mentors, instructors, and peers and engage in cultural meaning-making (Zhou et al., 2008).

Research supports the importance of intercultural exchanges for IGS. Hyun (2019, p. 59) interviewed 12 IGS who mentioned the need for supporters "who could understand them as who really they are" and their circumstances and difficulties with being an IGS. Among 195 male IGS at a Canadian university, Chapdelaine and Alexitch (2004) found that larger cultural differences in interaction styles between IGS' culture and Canadian culture resulted in a greater sense of "culture shock" partly through reduced social interaction with a variety of others. Sullivan and Kashubeck-West (2015) found that IS who valued both their own culture and relationships with host culture were more likely to forge such relationships and with other IS and, in turn, reported lower levels of acculturative stress. Rivas et al. (2019) found many narratives where international students expressed difficulty making friends or adjustments due to a lack of cultural awareness and communication, especially those involving domestic students. The lack of understanding of cultural differences often resulted in feelings of loneliness. Lin and Scherz (2014) found that one of the main themes that emerged impacting intercultural transitions was "cultural challenges" regarding social relationships, asking for help, and expectations for time. The research by Moores and Popaduik (2011) cited above also found an important cultural element in intercultural transitions of IGS where transitions were aided when the IGS had a "cultural guide" and interacted with contexts and individuals that contained elements of "cultural learning."

Research Propositions

Two of our interaction measures—Peer Interaction and Faculty Support—tapped into mostly culturally-neutral basic interactions like the above research. Our third interaction measure—Mentor Cultural Support—did have explicit measures of cultural support and according to cultural synergy and reciprocal adaptation should be more beneficial for IGS. The following research relationships were expected:

- *Proposition 1*: Those with greater Peer Interactions, Faculty Support, and Mentor Cultural Support will report higher levels of Cultural Congruity and University Environment Fit.

- *Proposition 2*: The positive associations for Mentor Cultural Support will be larger than those for Peer Interaction and Faculty Support.

METHODS

Participants

This survey-based quantitative study was part of a larger mixed-method National Science Foundation funded project under their Alliances for Graduate Education and the Professoriate program's Transformation track. Our study was designed jointly with a qualitative component to understand the socialization experiences of graduate students in STEM with a particular interest in underrepresented minorities and IGS. The Social Science Research Group (SSRG) designed and administered the Graduate Student Experience survey and followed the Tailored Design Method (Dillman et al., 2009) for rigor and reliability in all aspects of data collection and analyses. Institutional Review Board "Exempt" approval was granted in accordance with the Code of Federal Regulations, Part 46, section 101.

The SSRG sent the survey to a census of graduate students (n =13,180) in STEM programs at the 12 research universities. There were 4,012 respondents resulting in a response rate of 30%. Of these 4,012 students, there were 1,085 IGS representing 27% of the final sample. IGS status was determined by survey responses to a citizenship status question indicating "Citizen of another country, residing in the U.S. with a student visa or other nonresident visa." The 12 participating institutions were PWI, located in the Western and Mid-Western regions of the U.S., and met three criteria: (1) demonstrated success with the recruitment and retention of diverse students, (2) classified as research doctoral institutions where six were Very High Research Activity (R1) and six were Higher Research Activity (R2) activity, and (3) had graduate instructional programs and classified Carnegie as STEM Dominant (STEM/D) comprehensive programs without medical and veterinary school (CP), and comprehensive programs with medical and veterinary schools (CP/Med/Vet).

The original survey was validated by SSRG in 2015 based on the entire sample of 4,012 domestic and international students. All items used to create original indices were drawn from existing well-validated instruments used on non-IS students. For our sub-sample of IGS, it was possible that the items that comprised each index clustered to create sub-indices. To test this, we conducted exploratory factor analyses and found that each analysis revealed that our outcome and predictor indices all displayed a simple structure, exceeded the eigenvalue-one criterion, and loaded on a single factor. For each measure, we created a composite additive index by summing the individual items and reported the corresponding Cronbach's alpha and eigenvalues.

Outcome Variables

The Cultural Congruity Index (α = 0.78; eigenvalue = 2.93) was a modification of the Cultural Congruity Scale used by Gloria and Robinson

Kurpius (1996) who demonstrated predictive validity. The index used nine of the original 13 items: (a) I feel that I have to change myself to fit in; (b) I try not to show the people around me who I really am; (c) I often feel like a chameleon, having to change who I am depending on the person I am with; (d) I feel that I am compatible with other students; (e) I can talk to my university/college friends about my family back home; (f) My personal values are in conflict with what is expected at school; (g) The way I speak and/or my physical appearance make it hard for me to fit in with other students; (h) I feel as if I belong on this campus; and (i) I can talk to my family back home about my struggles and concerns at school. All items were measured from 1 = Not at All True and 7 = Very True and seven items were reverse coded so higher scores indicated increased sense of Cultural Congruity.

The University Environment Fit Index ($\alpha = 0.91$; eigenvalue = 2.41) was a modification of the University Environment Scaled developed by Gloria and Robinson Kurpius (1996) who demonstrated predictive validity. Our index used seven of the original 14 items: (a) Class sizes are so large that I feel like a number; (b) I do not feel valued as a student on campus; (c) The university encourages/sponsors ethnic groups on campus; (d) The university seems to value minority students; (e) The university seems like a cold, uncaring place to me; (f) I feel as if no one cares about me personally on this campus; and (g) I feel comfortable in the university environment. The items were measured from 1 = Not at All True and 7 = Very True and two items were reversed coded so higher scores represented greater University Environment Fit.

Predictor Variables

Peer Interactions Index ($\alpha = 0.85$; eigenvalue = 3.71) used all seven measures from the Peer-Group Interactions Scale developed by Pascarella and Terenzini (1980), which demonstrated predictive and discriminant validity. They included: (a) Since coming to this university, I have developed close personal relationships with other students; (b) The student friendships I have developed at this university have been personally satisfying; (c) My interpersonal relationships with other students have had a positive influence on my personal growth, attitudes, and values; (d) My interpersonal relationships with other students have had a positive influence on my intellectual growth and interests in ideas; (e) It has been difficult for me to meet and make friends with other students; (f) Students would be willing to listen to me and help if I had personal problems; (g) 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. The items were measured from 1 = Strongly Disagree and 5 = Strongly Agree. One response reverse coded so higher scores indicated greater levels Peer Interactions.

Faculty Support Index ($\alpha = 0.91$; eigenvalue = 3.96) combined six items from the two Faculty scales developed and validated by Pascarella and Terenzini (1980) and included: (a) My non-classroom interactions with faculty have had a positive influence on my personal growth, values, and attitudes; (b) My non-classroom interactions with faculty have had a positive influence on my career goals and

aspirations; (c) Since coming to this university, I have developed a close personal relationship with at least one faculty; (d) I am satisfied with the opportunities to interact informally with faculty; (e) 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; and (f) The faculty I have had contact with are interested in helping students grow in more than just academic areas. All statements were measured from where 1 = Strongly Disagree and 5 = Strongly Agree. Higher scores represented greater levels of non-academic Faculty Support.

The 5-item Mentor's Cultural Support Index ($\alpha = 0.90$; eigenvalue = 3.35) tapped psycho-sociocultural aspects of the mentoring relationship where predictive validity was demonstrated by (Brazill et al., 2022). SSRG developed three new items informed by research on the role of family and culture for persistence of American Indian and female graduate students in science and engineering (Guillory & Wolverton, 2008; Museus & Quaye, 2009; Shottonet al., 2007). The items that measured Mentor's Cultural Support included the statements "Is interested in my culture," "Is tolerant about any cultural differences between us," and "Appreciates cultural diversity." The two other items were modified from an item on the Career WISE survey (Prime et al., 2015) and included "My advisor is interested in me beyond my academic role," and "My advisor is friendly toward my family." All five statements were measured where 1 = Strongly Disagree and 5 = Strongly Agree. Higher scores represented greater levels of Mentor Cultural Support.

Control Variables

With few extant quantitative research on IGS that incorporated our predictor or outcome variables, we relied on IGS adjustment research reviewed by Wang (2009) and on IGS sense of belonging by Curtin et al. (2013) to inform our choice of covariates. Gender was self-reported by the respondents with a binary question offered in the survey (0 = male and 1 = female). Age was captured with a variable where 1 = 18-21 years old to 6 = over 40 years old. We used six race/ethnicity categories from the survey. Even though Asian/Pacific Islander was the largest category, we choose White/Caucasian as the reference category given that our 12 institutions were PWIs. Additional control variables included (a) graduate level coded as whether Doctoral (0 = no; 1 = yes); (b) student's year in school (1 = first year to 6 = 6 or more years); (c) first STEM student in family (0 = no; 1 = yes); (d) whether married (0 = no; 1 = yes); (e) number of dependents (0 to 2 or more); and (f) parent's highest education level (1 = high school diploma/GED to 8 = doctorate degree).

We included two variables to tap the larger academic environments among the IGS. If the Basic Carnegie Classification of the institution was R1: Doctoral Universities – Highest Research Activity (vs. R2: Doctoral Universities – Higher Research Activity) (0 = no; 1 = yes). Then, we collapsed the nine measured STEM fields into Biglan's (1973) four disciplinary "Hard" categories: (1) Pure Life (e.g., Biology, Physiology), (2) Pure Nonlife (e.g., Mathematics, Chemistry), (3) Applied Life (e.g., Agriculture, Medicine), and (4) Applied Nonlife (e.g., all

Engineering fields, Computer Science). The Biglan classification captured differences in socialization and culture in disparate STEM fields, especially labs (Rodriguez et al., 2022).

Statistical Adjustments and Procedures

Of the 1,085 IGS in the sample, we omitted 68 due to incomplete surveys and 19 who did not report their age, race, and/or sex. The final analytical sample was 998 IGS. The rates of missing values among control variables and items in our five indices were extremely low, ranging from 0.0% to 3.3% with 33% of the individual items below 1.0%. We analyzed patterns of missing data following Enders (2010) and did not find any statistically significant patterns based on our demographic variables. For these reasons, we conservatively concluded that the missing values were certainly missing at random (MAR). Following Johnson and Young (2011) we used multiple imputation methods to generate values for missing data through the multivariate normal regression (*mvn*) option in Stata that used a Markov Chain Monte Carlo procedure to generate the 20 imputed datasets as suggested by StataCorp (2021).

We used Ordinary Least Squares (OLS) regression techniques to estimate two models for each outcome measure. Model 1 included our control variables. Model 2 then added three focal predictors of Peer Interaction, Faculty Support, and Mentor Support to Model 1. We chose to include all three of the focal predictors in Model 2 for two reasons. First, all three occured simultaneously in the students' lives and regression equations should best strive to capture the participants' lived realities. Second, this simultaneous modeling approach produced more conservative net estimates of the associations between our focal and outcome variables. We calculated robust standard errors to adjust for clustering within the 12 institutions that may have produced artificially low p-values. We used three measures of effect sizes: (a) standardized regression coefficients for the focal predictor indices to estimate relative effects and partial eta^2 to estimate their contributions to R^2, and (b) Cohen's f^2 to estimate the effect sizes of the overall regression models.

A series of regression diagnostics were performed to test the assumptions for OLS including normality, multicollinearity, homoscedasticity, and influential observations. No violations emerged. Diagnostic tests (residual histogram and normality and Q-Q plots, leverage, and Cook's D) suggested that our standard errors were normally distributed and there were no influential observations. Zero-order correlations revealed that multicollinearity was not present among the study variables.

RESULTS

Descriptive Statistics

Table 1 displays all the analytical variables. The STEM IGS reported moderately high levels of both Cultural Congruity (M=45.13) and University Environment Fit (M=37.66). The IGS also reported healthy levels of supportive interactions with peers (M=24.47), faculty (M=21.55), and mentors (M=17.76). The standard deviations for all indices revealed a fair amount of variability from student-to-student.

The composition of our STEM IGS included 38% who were female and an average age category of 25 – 30 years old. For race, Asian/Pacific Islander was the largest group at 66% followed by Black/African American and White/Caucasian (9.7% each), Hispanic/Latino (7.9%), Arab/Middle Eastern (6.5%), and Other (5.8%). About 72% of our IGS were currently in Doctoral programs and between a 2nd and 3rd year student. Interesting, 52% reported that they were the first in their family to pursue a STEM degree. Nearly one-third of the students were married and had on average about 1.5 dependents. Our average IGS was surpassing his or her parents' highest education level, which was just above an Associate's degree. Lastly, 75% of our IGS attended an R1 institution and were most likely to be in a STEM field classified as Applied Nonlife (50%).

Regression Statistics

Table 2 contains the OLS estimates. We presented standardized coefficients and partial eta^2 for the three focal predictor indices to directly compare the effect sizes and statistically evaluate our first and second research propositions. We presented the unstandardized coefficients for the control variables as these are easier to interpret with dummy and binary coded variables.

For Cultural Congruity, the results in Model 1 showed few statistically significant control variables. A notable result is that compared to White/Caucasian students Asian/Pacific Islanders reported levels of Cultural Congruity that were more than two points lower. The low R^2 and Cohen's f^2 values show that this set of variables were weak predictors of Cultural Congruity levels. Taken together, these variables explained only 3% of the individual-level variation in Cultural Congruity.

In Model 2, our three focal predictor indices were added to the regression model and revealed that STEM IGS reported statistically higher levels of Cultural Congruity when they interacted more with all three support agents: peers, faculty, and mentors. These results provided support for Proposition 1. However, the standardized coefficients and partial eta^2 did not provide support for our argument in Proposition 2 that Mentor Cultural Support would have a larger effect size than Peer Interaction and Faculty Support. Instead, Peer Interaction emerged as the strongest predictor of Cultural Congruity: for each one standard deviation increase in Peer Interaction IGS reported on average a 0.44 standard deviation increase in levels of Cultural Congruity, which was an effect size close to "strong" (0.50)

Table 1: Descriptive Statistics for Study Variables: International Graduate Students in U.S. STEM Programs, 2015 – 2017 (*n* = 998).

Variable	Coding	M or %	SD
Outcomes Indices			
Cultural Congruity (α = 0.78)	7 – 63	45.13	9.07
University Environment Fit (α = 0.91)	7 – 49	37.66	7.22
Focal Predictor Indices			
Peer Interaction (α = 0.85)	5 – 35	24.47	5.14
Faculty Support (α = 0.91)	5 – 30	21.55	5.08
Mentor Cultural Support (α = 0.90)	5 – 25	17.76	4.88
Controls			
Female	0 = no; 1 = yes	38%	---
Age	1 – 6	3.08	0.83
Arab/Middle Eastern	0 = no; 1 = yes	6.5%	---
Asian/Pacific Islander	0 = no; 1 = yes	66%	---
Black/African American	0 = no; 1 = yes	9.7%	---
Hispanic/Latino	0 = no; 1 = yes	7.9%	---
White/Caucasian (reference)	0 = no; 1 = yes	9.7%	---
Other	0 = no; 1 = yes	5.8%	---
Doctoral	0 = no; 1 = yes	72%	---
Year in School	1 – 6	2.56	1.51
First STEM Student in Family	0 = no; 1 = yes	52%	---
Married	0 = no; 1 = yes	30%	---
Number of Dependents	0 – 2	1.49	0.99
Parents' Highest Education Level	1 – 8	4.22	2.19
R1 Institution	0 = no; 1 = yes	75%	---
Pure Life	0 = no; 1 = yes	19%	---
Pure Nonlife	0 = no; 1 = yes	24%	---
Applied Life	0 = no; 1 = yes	7.0%	---

Applied Nonlife (reference)	0 = no; 1 = yes	50%	---

according to Acock (2018). The effect sizes for Faculty Support and Mentor Cultural Support were "weak" (0.10) at 0.13 and 0.09 standard deviations, respectively.

These three indices improved the amount of variation explained with an R^2 = 29%: 26-percentage points higher than Model 1. For Cohen's f^2, the increase in R^2 from Model 1 resulted in an effect size of 0.36 that is "large" according to Cohen (2013) and can be attributed to the combined addition of the three institutional agent variables. The partial eta^2 values confirmed the importance of Peer Interaction as this variable accounted for 0.17 of the R^2 value of 0.29. Faculty and Mentor Cultural Support contributed at lower rates: 0.05 and 0.03, respectively.

The results for University Environment Fit revealed similar patterns in a set of companion regression models. Model 1 showed that our control variables were weak individual and global predictors of University Environment Fit levels with an f^2 and R^2 of only 0.04 (contributing 4% of explained variance). Again, Asian/Pacific Islander STEM IGS reported statistically lower levels than their White/Caucasian counterparts.

The results in Model 2 demonstrated that higher levels of Peer Interaction, Faculty Support, and Mentor Cultural Support were all statistically associated with higher reports of University Environment Fit among STEM IGS—supporting Proposition 1. Again, though, the standardized coefficients and partial eta^2 did not provide support for our argument in Proposition 2 that Mentor Cultural Support would have a larger effect size than Peer Interaction and Faculty Support. Peer Interaction again emerged as the strongest predictor, this time for University Environment Fit. For each one standard deviation increase in Peer Interaction IGS reported on average a 0.45 standard deviation increase in levels of Cultural Congruity, which was an effect size close to "strong." The effect size of 0.21 for Faculty Support was between "weak" and "moderate" (0.30) and of 0.18 for Mentor Cultural Support was "weak."

Together, these three indices improved the amount of variation explained with an R^2 = 32%: 28-percentage points higher than Model 1. For Cohen's f^2, the increase in R^2 from Model 1 resulted in an effect size of 0.41 that is "large" and can be attributed to the combined addition of the three institutional agent variables. The partial eta^2 values confirmed the importance of Peer Interaction as this variable accounted for 0.16 of the R^2 value of 0.32 where Faculty and Mentor Cultural Support contributed at lower rates: 0.07 and 0.05, respectively.

Table 2: Regression Statistics: International Graduate Students in U.S. STEM Programs, 2015 – 2017 (*n* = 998).

Variable	Cultural Congruity		University Environment Fit	
	Model 1	Model 2	Model 1	Model 2
Focal Predictor Indices				
Peer Interaction	---	0.44*** (0.17)	---	0.45*** (0.16)
Faculty Support	---	0.13** (0.05)	---	0.21*** (0.07)
Mentor Cultural Support	---	0.09* (0.03)	---	0.18** (0.05)
Controls				
Female	0.10	0.13	0.23	0.23
Age	0.53	0.58	0.34	0.34
White/Caucasian (reference)	---	---	---	---
Arab/Middle Eastern	-1.27	-1.13	-0.27	-0.29
Asian/Pacific Islander	-2.22***	-2.54***	-1.32**	-1.24**
Black/African American	-1.01	-0.80	-0.09	-0.12
Hispanic/Latino	0.28	0.25	1.01	0.88
Other	0.81	0.87	-0.47	-0.55
Doctoral	0.73	0.60	1.23**	0.79*
Year in School	0.43*	0.39*	0.29	0.25
First STEM Student in Family	-0.14	-0.16	0.40	0.38
Married	1.90**	1.25*	0.66	0.73
Number of Dependents	-0.33	-0.25	-0.51*	-0.48*
Parents' Highest Education Level	0.48**	0.20*	0.08	0.09
R1 Institution	0.60	0.51	-0.67	-0.67
Applied Nonlife (reference)	---	---	---	---
Pure Life	-1.16	-1.08	-0.09	-0.09
Pure Nonlife	-0.29	-0.29	-0.32	-0.32
Applied Life	-0.39	-0.43	-0.90	-0.90

Constant	20.76	20.05	38.76	18.11
R^2/Eta^2	0.03	0.29	0.04	0.32
Cohen's f^2	0.03	0.36	0.04	0.41

Note. Standardized coefficients presented for Focal Predictor Indices. Unstandardized coefficients presented for Control variables. Partial eta^2 in parentheses.
* $p < .05$. ** $p < .01$. *** $p < .001$ (2-tailed tests).

DISCUSSION

Our findings and implications must be interpreted withing the limitations of our study. First, our data were collected pre-COVID-19 and thus did not capture the corresponding institutional changes in higher education and especially for IGS (Sustarsic & Zhang, 2022). Second, these data were collected with a cross-sectional design so standards of causality could not be satisfied statistically. Third, we did not measure English language fluency that has emerged as a consistently strong predictor of the adjustment of IGS (Rodriguez et al., 2019). Fourth, our sample was large at about 1,000 IGS but not a true random sample. However, our sample did closely mirror the national demographic profile of IGS. For example, our STEM IGS sample contained 38% females whereas the national average was 37.2% (NSF, 2021) and we had 66% who reported their ethnicity to be "Asian/Pacific Islander" whereas the national average was about 70% and 6.5% who reported "Arab/Middle Eastern" with a national average of 6.0% (IIE, 2022).

Significance and Educational Implications

Our goal in this research is to provide a quantitative baseline study on the role of institutional agents in providing support to STEM IGS as they transition interculturally into their institutions. The contributions of our research are threefold: methodologically, statistically, and substantively. Methodologically and statistically, our quantitative research is the first to: (a) use one-of-a-kind survey data from nearly 1,000 STEM IGS at 12 predominately PWIs; (b) statistically estimate the relative individual and combined associations and effect sizes of supportive interactions with peer, mentor, and faculty on two measures of cultural fit; (c) incorporate a range of covariates to uncover any demographic, family, or institutional associations; and (d) employ missing value strategies to reduce estimation biases.

Substantively, our methods and statistics allow us to determine whether support from peers, mentors, or faculty is more important to STEM IGS' perceptions of cultural fit. Based on our conceptual framework, we anticipate that Mentor Cultural Support will outperform support from the other two institutional agents. This contribution provides an important addition to prior research reviewed above that has not definitively tested this proposition. Our research supplies a first test of this proposition and finds that Peer Interactions are by far

the most statistically important supportive relationship for better perceived Cultural Congruity and University Environment Fit. This is demonstrated by the variable's strong effect size and oversized contribution to R^2. We do find that support from faculty and mentors are also statistically important, though effect sizes and contributions to R^2 are smaller than that of Peer Interactions. The demonstrated quantitative importance of support from peers may guide institutions in how they prioritize resources. Our findings go far in supporting qualitative research on the importance of peer support for IGS (Moore & Popadiuk, 2011; Rivas et al., 2019) and others who advocate for the need for such mentoring programs (Veliz, 2020).

Our index for Mentor Cultural Support that explicitly taps intercultural processes has the smallest effect sizes suggesting that cultural elements do not provide added value within supportive interactions, at least among our sample and measures. This finding does not necessarily contradict either the Cultural Synergy or Reciprocal Adaptation approaches or prior research on the importance of culture (Hyun, 2019) but does highlight that interactions that contain intercultural elements may need specific components beyond being "tolerant" or "appreciative" of cultural differences—components included in our measure of Mentor Cultural Support as well as those in previous studies. Another substantive contribution is that the combined individual characteristics of STEM IGS contribute little to understanding differences in cultural fit as shown by the meager R^2/f^2 values and the few statistical associations.

We consider the most important substantive contribution to be the statistical finding that *all three* institutional agents combined constitutes the largest explanatory role in STEM IGS' cultural fit. The effect sizes of Model 2 are large with nearly all variance explained accounted for by the combined package of peer, mentor, and faculty support. This finding may have the most relevance for educational practices and future research. While we demonstrate statistically this result, our data cannot explain the processes underlying this finding. To provide a possible explanation, we return to Moores and Popaduik (2011) who find that "cultural guides" aid in the intercultural transitions of IGS. There is a conceptual counterpart to this finding termed "navigational capital" that Yosso (2005) argues is needed by Students of Color to navigate through social institutions that may be hostile to and not created culturally for them. This may capture the situation of IGS, especially those at PWIs, who often cite cultural barriers and constraints as issues in intercultural transitions (Lin & Scherz, 2014).

Our study suggests that peers, mentors, and faculty may be a source of social capital (i.e., cultural guides) to help cultivate navigational capital in STEM IGS. Indeed, Yosso (2005, p. 79) avers that social capital is a network of peers and agents who provide "instrumental and emotional support to navigate through society's institutions." Looking at the wording of our items for the indices of Peer Interactions and Mentor Cultural and Faculty Support, many tap into these qualities of instrumental and emotional support, especially items for the Peer Interactions index—perhaps explaining why these interactions are so important for STEM IGS' reports of Cultural Congruity and University Environment Fit. Recent qualitative research from Pumacchahua and Rogers (2022) in interviews

with Latinx and Black STEM Ph.D. students at PWIs in the U.S. find overwhelmingly that they attribute their social and navigational capital for their academic success and ability to navigate racial slights and hostility and especially microaggressions (73%). Over half of the students mention a mix of peers, faculty, mentors, and advisors as important institutional agents. For advice in navigating the PWI, 67% of the STEM doctoral students mention the need to find a support system with one student noting: "Find support groups within other graduate student groups. I felt like I definitely maintained my sanity during all the other obstacles I was going through because of them." (p. 10).

However, Sustarsic & Zhang (2022) find that IGS with less access, knowledge, and motivation to seek micro-level support agents may rely more on macro-level programs and practices or even rely on strategies that are too self-reliant. Thus, a two-tiered approach to building IGS' navigational capital and resulting cultural fit is required that embeds programs of peers/mentor/faculty support within macro-institutional resources. These institutional resources are vital given that Moon et al. (2020) find that IGS are overwhelmingly disappointed with such macro-level resources geared toward IGS. Lastly, practices aimed at developing navigational capital should include domestic graduate students as the adjustment and satisfaction of IGS are greater when they interact with their U.S. peers, although relatively few IGS interacted with these domestic peers (Rivas et al., 2019; Veliz, 2020). Without these interactions, IGS may feel racialized and ethnicized on PWI (Suspitsyna, 2013), compromising the benefits they confer to other students, faculty, departments, and institutions.

REFERENCES

Abegaz, M., Lahiri, S., & Mahbub Morshed, A.K.M. (2020). Does the presence of international students improve domestic graduations in the US? *The Quarterly of Economics and Finance, 75,* 95-108. https://doi.org/10.1016/j.qref.2019.05.008

Acock, A. (2018). *A Gentle introduction to Stata.* Stata Press.

Anderson, S. (2014). International students are vital to U.S. higher education. *International Educator, 14,* 4-8.

Antony, J.S., & Schaps, T.L. (2021). The more things change the more they stay the same. In L. W. Perna (Ed.), *Higher education: Handbook of theory and research 36* (pp. 383-417). Springer. https://doi.org/10.1007/978-3-030-44007-7_9

Brazill, S.C., Myers, C.B., Myers, S.M., & Johnson, C.M. (2022). Cultural congruity and academic confidence of American Indian graduate students in STEM: Peer interactions, mentor cultural support, and university environment fit. *Journal of Diversity in Higher Education,* Advance online publication. https://doi.org/10.1037/dhe0000353

Chapdelaine, R.F., & Alexitch, L.R. (2004). Social skills difficulty: Model of culture shock for international graduate students. *Journal of College Student Development, 45(2),* 167-184. https://doi.org/10.1353/csd.2004.0021

Chellaraj, G., Maskus, K.E., & Mattoo, A. (2008). The contribution of international graduate students to U.S. innovation. *Review of International Economics, 16(3),* 444-462. https://doi.org/10.1111/j.1467-9396.2007.00714.x

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge Academic.

Cortazzi, M., & Jin, L. (1997). Communication for learning across cultures. In R. Harris & D. McNamara (Eds.), *Overseas students in higher education* (pp. 76–90). Routledge. https://doi.org/10.4324/9780203040065

Council of Graduate Schools. (2008). *Analysis of baseline data from the Ph.D. Completion Project.* Council of Graduate Schools. https://cgsnet.org/wp-content/uploads/2022/01/phd_completion_and_attrition_analysis_of_baseline_demographic_data-2.pdf

Curtin, N., Stewart, A. J., & Ostrove, J. M. (2013). Fostering academic self-concept: Advisor support and sense of belonging among international and domestic graduate students. *American Educational Research Journal*, *50*(1), 108–137. https://doi.org/10.3102/0002831212446662

Dillman, D.A., Smyth, A.J., & Christian, L.M. (2009). *Internet, mail, and mixed mode surveys: The Tailored Design Method (3rd).* Wiley and Sons.

García, H. A., Garza, T., & Yeaton-Hromada, K. (2019). Do we belong? A conceptual model for international students' sense of belonging in community colleges. *Journal of International Students*, *9*(2), 460–487. https://doi.org/10.32674/jis.v9i2.669

Gloria, A. M., Castellanos, J., & Herrera, N. (2016). The reliability and validity of the cultural congruity and university environment scales with Chicana/o community college students. *Community College Journal of Research and Practice*, *40*(5), 426–438. https://doi.org/10.1080/10668926.2015.1066276

Gloria, A. M., & Robinson Kurpius, S. E. (1996). The validation of the cultural congruity scale and the university environment scale with Chicano/a students. *Hispanic Journal of Behavioral Sciences*, *18*(4), 533–549. https://doi.org/10.1177/07399863960184007

Guillory, R. M., & Wolverton, M. (2008). It's about family: Native American student persistence in higher education. *The Journal of Higher Education, 79(1),* 58–87. https://doi.org/10.1353/jhe.2008.0001

Han X., Stocking, G., Gebbie, M.A., & Appelbaum, R.P. (2015). Will they stay or will they go? International graduate students and their decisions to stay or leave the U.S. upon graduation. *PLoS ONE, 10(3)*, 1-18. https://doi.org/10.1371/journal.pone.0118183

Han, X., & Appelbaum, R.P. (2016). *Will they stay or will they go: International STEM students are up for grabs*. Ewing Marion Kauffman Foundation. https://www.kauffman.org/wp-content/uploads/2019/12/STEM_Students_FINAL.pdf

Hyun, S.H. (2019). International graduate students in American higher education: Exploring academic and non-academic experiences of international graduate students in non-STEM fields. *International Journal of Educational Research, 96,* 56-62. https://doi.org/10.1016/j.ijer.2019.05.007

Institute of International Education (IIE). (2022). *Annual release: International students. https://opendoorsdata.org/annual-release/international-students/*

Johnson, D.R., & Young, R. (2011). Towards best practices in analyzing datasets with missing data: Comparisons and recommendations. *Journal of Marriage and Family, 73(5),* 926-45. https://doi.org/10.1111/j.1741-3737.2011.00861.x

Li, Y., Wang, K., Xiao, Y., & Froyd, J.E. (2020). Research and trends in STEM education: A systematic review of journal publications. *International Journal of STEM Education, 7(11),* 1-16. https://doi.org/10.1186/s40594-020-00207-6

Lin, S.-Y., & Scherz, S.D. (2014). Challenges facing Asian international graduate students in the US: Pedagogical considerations in higher education. *Journal of International Students*, *4*(1), 16–33. https://doi.org/10.32674/jis.v4i1.494

Moon, C.Y., Zhang, S., Larke, P., & James, M. (2020). We are not all the same: A Qualitative analysis of the nuanced differences between Chinese and South Korean International Graduate students' experiences in the United States. *Journal of International Students, 10(1), 28–49. https://doi.org/10.32674/jis.v10i1.770*

Moores, L., & Popadiuk, N. (2011). Positive aspects of international student transitions: A qualitative inquiry. *Journal of College Student Development*, *52(3),* 291-306. doi:10.1353/csd.2011.0040.

Museus, S. D., & Quaye, S. J. (2009). Toward an intercultural perspective of racial and ethnic minority college student persistence. *The Review of Higher Education, 33(1),* 67–94. https://doi.org/10.1353/rhe.0.0107

National Academies of Sciences, Engineering, and Medicine (NAS). (2018). *Graduate STEM education for the 21st Century*. The National Academies Press. https://nap.nationalacademies.org/catalog/25038/graduate-stem-education-for-the-21st-century

National Foundation for American Policy (NFAP). 2021. *International students in science and Engineering*. NFAP. https://nfap.com/wp-content/uploads/2021/08/International-Students-in-Science-and-Engineering.NFAP-Policy-Brief.August-2021.pdf

National Science Foundation. (2021b). *Doctorate recipients from U.S. universities: 2020*. NSF 22-300. NSF. https://ncses.nsf.gov/pubs/nsf22300/.

Pascarella, E. T., & Terenzini, P. T. (1980). Predicting freshman persistence voluntary dropout decisions from a theoretical model. *The Journal of Higher Education*, *51*(1), 60–75. https://doi.org/10.2307/1981125

Prime, D. R., Bernstein, B. L., Wilkins, K. G., & Bekki, J. M. (2015). Measuring the Advising Alliance for female graduate students in science and engineering: An emerging structure. *Journal of Career Assessment*, *23*(1), 64–78. https://doi.org/10.1177/1069072714523086

Pumaccahua, T., & Rogers, M.R. (2022). Academic warriors: Community cultural wealth among Latinx and Black STEM doctoral students at predominately White institutions. *Journal of Latinos and Education (Online First)*. https://doi.org/10.1080/15348431.2022.2057988

Regets, M.C. (2007). Research issues in the international migration of highly skilled workers: a perspective with data from the United States. (Working paper / SRS, 07-203). National Science Foundation. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-312665

Rivas, J., Burke, M., & Hale, K. (2019). Seeking a sense of belonging: Social and cultural integration of international students with American college students. *Journal of International Students*, *9*(2), 682–704. https://doi.org/10.32674/jis.v9i2.943

Rodriquez, C., Chavez, C.R., & Klauber, C. (2019). International graduate student challenges and support. *International Research and Review, 8(2),* 49-64.

Rodriguez, S. L., Perez, R. J., & Schulz, J. M. (2022). How STEM lab settings influence graduate school socialization and climate for students of color. *Journal of Diversity in Higher Education, 15*(1), 58–72. https://doi.org/10.1037/dhe0000361

Shih, K. (2017). Do international students crowd-out or cross-subsidize Americans in higher education? *Journal of Public Economics, 156,* 170-184. https://doi.org/10.1016/j.jpubeco.2017.10.003

Shotton, H. J., Oosahwe, E. S. L., & Cintrón, R. (2007). Stories of success: Experiences of American Indian students in a peer-mentoring retention program. *The Review of Higher Education, 31*(1), 81– 107. https://doi.org/10.1353/rhe.2007.0060

StataCorp. 2021. *Stata multiple-imputation reference manual: Release 17*. Stata Press.

Sullivan, C., & Kashubeck-West, S. (2015). The interplay of international students' acculturative stress, social support, and acculturation modes. *Journal of International Students*, *5*(1), 1–11. https://doi.org/10.32674/jis.v5i1.438

Suspitsyna, T. (2013). Socialization as sensemaking: A semiotic analysis of international graduate students' narratives in the USA. *Studies in Higher Education, 38(9),* 1351– 1364. https://doi.org/10.1080/03075079.2011.629343

Sustarsic, M., & Zhang, J. (2022). Navigating through uncertainty in the era of COVID-19: Experiences of international graduate students in the United States. *Journal of International Students*, *12*(1), 61-80. https://dio.org/10.32674/jis.v12i1.3305

Veliz, D. (2020). The socialization of international doctoral students in the USA. In J. C. Weidman& L. DeAngelo (Eds.), *Socialization in higher education and the early career: Theory, research, and application* (pp. 149-160). Springer. https://doi.org/10.1007/978-3-030-33350-8

Wang, J. (2009). A study of resiliency characteristics in the adjustment of international graduate students at American universities. *Journal of Studies in International Education*, *13(1),* 22–45. https://doi.org/10.1177/1028315307308139

Winkle-Wagner, R., McCoy, D., & Lee-Johnson, J. (2020). Creating porous ivory tower: Two-way socialization processes that embrace Black students' identities in academia. In J. Weidman & L.DeAngelo (Eds.), *Socialization in*

higher education and the early career: Theory, research, and application. (pp. 73-89). Springer. https://doi.org/10.1007/978-3-030-33350-8

Yosso, T.J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education, 8(1)*, 69-91, https://doi.org/10.1080/1361332052000341006

Zhou, Y., Topping, K., Jindal-Snape, D., & Todman, J. (2008). Theoretical models of culture shock and adaptation in international students in higher education. *Studies in Higher Education*, *33*(1), 63–75. https://doi.org/10.1080/03075070701794833

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