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Culture and Context's Influence on Hispanic Undergraduates' Perceptions of Their Persistence toward STEM Degree Attainment

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CULTURE AND CONTEXT'S INFLUENCE ON HISPANIC UNDERGRADUATES' PERCEPTIONS OF THEIR PERSISTENCE TOWARD STEM DEGREE ATTAINMENT

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Elsa I. Bravo

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To: Dean Michael Heithaus
College of Arts, Sciences & Education

This dissertation, written by Elsa I. Bravo, and entitled Culture and Context's Influence on Hispanic Undergraduates' Perceptions of Their Persistence Toward STEM Degree Attainment, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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and Dean of the University Graduate School

Florida International University, 2021

DEDICATION

In loving memory of Jennifer Cordero

In your words, you allowed me to appreciate the beauty in every moment and to develop the strengths buried in the deepest corners of my heart

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ABSTRACT OF THE DISSERTATION

CULTURE AND CONTEXT'S INFLUENCE ON HISPANIC UNDERGRADUATES' PERCEPTIONS OF THEIR PERSISTENCE TOWARD STEM DEGREE ATTAINMENT

by

Elsa I. Bravo

Florida International University, 2021

Miami, Florida

Professor Dionne P. Stephens, Major Professor

This dissertation examines the influences of context and culture on Hispanic undergraduates in the STEM pipeline. Study one utilized systematic review methods to assess the effectiveness of STEM intervention programs on Hispanic undergraduates. A total of 45 STEM related databases were searched from March-September 2020 with no limitations. Although a total of 259 studies were identified, only one study was actually found to specifically focus on Hispanic populations and include empirically based evaluations. The one remaining study did not find a statistically significant intervention effect for four-year graduation rates. This lack of evidence highlights a gap in research for tackling increased representation for Hispanic students in STEM and identifies the need for methodological changes in the way STEM interventions are evaluated.

Study two utilized qualitative content analysis methods to identify Hispanic STEM majors' perceptions of both supports and barriers in their STEM degree pathways. Two short answer questions exploring barriers and supports were asked of 947 Hispanic undergraduate STEM majors. Our findings revealed nuanced perspectives that highlight

the importance of financial access and family, teacher, and peer support, as well as acknowledgement for the role of experiences unique to Hispanic groups. These findings illuminate the importance of respect and inclusion of Hispanic culture with regards to increasing Hispanic representation in STEM.

Study three examined how cultural factors influence Hispanic undergraduates' perception of themselves and career aspirations using the integrative theoretical models of Relational Developmental Systems Theory (RDST) and Relational Cultural Theory (RCT). A total of 947 Hispanic undergraduates completed an ethnic identity, *familismo* beliefs, career aspirations, STEM retention, and STEM identity questionnaires. Structural Equation Modeling (SEM) analyses revealed model relationships were significant and positive for both Hispanic men and women; however, these models differed in strength of relationships among some of the constructs.

TABLE OF CONTENTS

LIST OF TABLES

TABLES PAGE

LIST OF FIGURES

FIGURES PAGE

I. INTRODUCTION

In the United States (U.S.) the fields of Science, Technology, Engineering, and Math—collectively referred to as STEM—have been at the forefront of discussions about education and national training reputation (U.S Government Accountability Office, 2018). The National Institutes of Health (NIH, 2018) Interest in Diversity Statement asserts that the scientific workforce needs to continue to be diverse in order for the U.S to maintain its competitive edge. This reflects a desire to address empirical research findings which have shown that racial, ethnic, and gender diversity have a multitude of positive influences on business and academic outcomes in areas spanning audience base, productivity, and profits (Ali et al., 2011; Herring, 2009; Muchiri & Ayoko, 2013). Initiatives such as The National Science and Technology Council (2018) state that STEM fields would benefit from the inclusion of more minorities because more innovations and technology could be realized. STEM fields' inability to recruit and retain minorities will directly impact their ability to achieve these goals.

The STEM workforce has grown by 79% in the past two decades through additional opportunities for training, STEM fields' higher than average salaries, and greater career mobility (Pew Research, 2018). However, despite these trends, there continues to be significant racial, ethnic and gender disparities in STEM participation across the academic and career pipeline. Although they are the fastest growing minority group in the United States, Hispanics[1]

[1] The authors recognize that there is disagreement in how the term Hispanic is applied and used to identify Spanish speakers (Suro, 2006). However, despite its frequent incorrect use, the authors have chosen to use the term Hispanic in the present study because the research participants self-identify as Hispanic (Fry & Lopez, 2012).

only comprise approximately 7% of the STEM workforce (Pew Research, 2018). When gender is considered, the disparity becomes even more pronounced, with Hispanic women representing only 2% and Hispanic men only 4% of the STEM workforce (National Science Foundation, 2017).

Researchers are increasingly attempting to identify what factors contribute to these disparities. It has been posited that educational experiences are critical to consider. These include early developmental experiences involving lower quality and limited access to science curriculum and lacking same-gender and same-ethnicity role models in elementary school and high school (Irizarry & Donaldson, 2012; San Miguel & Kim, 2015; Young, 2005). Hispanic college students' persistence toward degree completion research has consistently found that financial responsibilities and economic disparities affect many Hispanic students' ability to enter and complete STEM degree programs (Aschbacher et al., 2010; Crisp & Nora, 2012; Grossman & Porche, 2014; Sy & Romero, 2008; Whalen & Shelly, 2010). This is concerning because participation in research laboratories, STEM-supportive programs, and other school-related opportunities are critical to success in STEM fields (Grossman & Porche, 2014; Meyers et al., 2011; Tyson et al., 2007).

Cultural barriers are another factor explored in the literature of general college persistence to degree completion. Research has found that ethnic identity and family networks are key components of Hispanic students' cultural values (Ceja, 2001, 2004, 2006). Research has already noted that familial messages about the importance of education not only influence Hispanic undergraduate students' academic performance, but the ethnic specificity of these messages significantly informs perceptions and

attitudes toward degree goals (Ceja, 2004, 2006; Grossman & Porche, 2014; Martinez, 2013; Niemann, 2004; Plunkett & Bámaca- Goméz, 2003; Sy & Romero, 2008). Further parental beliefs about educational pursuits and culturally informed identity factors (*familismo* and gender roles) shape perceptions of Hispanic students' ability to persist in their STEM degrees (Hanson, 2012; Hernandez et al., 2016). Unfortunately, there are no studies to date that specifically look at these Hispanic familial-level cultural influences among undergraduates pursuing STEM degrees.

Clearly, undergraduate Hispanic STEM majors' persistence is part of a larger process of degree and career exploration, which includes influences from cultural forces that can both support or discourage STEM exploration. The current project proposes that Hispanic college students' persistence in STEM is shaped by individual agency as well as messages from surrounding cultural systems and contextually unique factors. Through the integration of relational developmental systems (RDS) theory, this project seeks to identify the ways in which contextual and cultural factors serve as barriers and/or supports for Hispanic undergraduates in STEM degree programs. The three phases of this project were guided by the following: a focus on the state of current STEM interventions for Hispanic undergraduates at universities, allowing Hispanic undergraduates to share their lived experiences with barriers and support systems, and the influence of culture through the lens of Hispanic identity and family. The main aims of the present work are to (1) assess the effectiveness of interventions seeking to increase Hispanic undergraduates' participation in STEM fields, (2) identify what potential barriers and supports Hispanic STEM majors perceive as shaping their persistence in Hispanic-dominant contexts, and (3) identify the influence of culture on Hispanic undergraduates'

persistence in STEM. These findings will contribute to the development of interventions that focus on improving Hispanic undergraduates' success in STEM degree programs, as well as contributing to initiatives seeking to address gender, racial, and ethnic disparities across the STEM pipeline.

II. STUDY ONE: SYSTEMATICALLY EVALUATING THE EFFECTIVENESS OF UNDERGRADUATE STEM SUPPORT PROGRAMS FOR HISPANIC STUDENTS

Abstract

Numerous undergraduate programs support minority students' pursuit of STEM degrees but have not been widely evaluated. The current review sought to identify empirically-based evaluations of STEM interventions addressing underrepresentation of Hispanic undergraduates at four-year universities. A total of 45 STEM-related databases were searched from MarchSeptember 2020 with no limitations. Although a total of 259 studies were identified, only three studies were found that specifically focus on Hispanic populations and include empirically-based evaluations. Further, two of these were excluded because they grouped all racial- and ethnic-minority study data together in their results, failing to provide information specific to Hispanics. The one remaining study did not find a statistically significant intervention effect for four-year graduation rates. The lack of evidence highlights a gap in research for tackling increased representation for Hispanic students in STEM and identifies the need for methodological changes in the way STEM interventions are evaluated.

Keywords: Hispanic, undergraduate, STEM, intervention, systematic review

Underrepresented ethnic and racial minorities' (UREM) representation across STEM fields is disproportionate to that of their numbers in the U.S. general population. While UREMs make up approximately 30% of the U.S population their ethnic-minority groups each hold less than 15% of the positions across STEM job clusters (Pew Research, 2018). The NIH's Interest in Diversity Statement (2018) warns that the U.S STEM workforce must continue to remain diverse as unique perspectives, such as those brought by UREM, are needed to keep the U.S competitive in STEM globally and, ultimately, to address the unique scientific problems that arise. Empirical research findings show that racial, ethnic, and gender diversity have a multitude of positive influences on business and academic outcomes in areas ranging from audience base and productivity to profits (Ali et al., 2011; Herring, 2009; Muchiri & Ayoko, 2013). The advantages that a diverse workforce can provide are particularly important to consider in STEM fields as public engagement, producing relevant research, and improving quality of life are central to its overarching goals. STEM fields' inability to recruit and retain UREM will therefore directly impact the ability to achieve these goals.

Programs to enhance undergraduate participation in STEM fields ultimately gained ground in addressing some of these issues with the passing of the America COMPETES Act (2007) and opened the door for multi-year grants for STEM support programs. Funding between 2010 to 2016 for these STEM programs remained unchanged despite reports showing a decrease in available programs from 209 in 2010 to 163 in 2016 (United States Government Accountability Office, 2018). Research has noted that programs that provide access to research opportunities, integrate parental support, and offer mentorship for UREM are more likely to have more successful outcomes (Eagan et

al., 2010; Griffith, 2010; San Miguel & Kim, 2015). It is possible that the inclusion of these efforts can increase STEM degree attainment, representation in STEM fields, and entrance into higher paying jobs.

These programs are especially important for Hispanic groups as only approximately 8% of the STEM workforce self-identified as Hispanic in 2014 (U.S Department of Education, 2015). These trends persist in undergraduate levels, as only 15% of Hispanic students were awarded a STEM bachelor's degree in the 2015-2016 school year (National Center for Education Statistics [NCES], 2019). While Hispanics do graduate with STEM degrees, STEM workforce representation rates for Hispanic groups appear to remain low (Pew Research, 2018). Little is known as to why there is a gap between postsecondary degree attainment and entrance into the workforce.

To address this void there have been numerous efforts to support UREM students' entry into, retention in and graduation from STEM degree programs, including Ronald E. McNair Fellowships, RISE, and others. These efforts focus on four-year universities as these provide the foundational training for the next step in the academic pipeline to graduate STEM degree programs (McNair Scholars Program, n.d). While programs have been successful at increasing Hispanic college students' participation in STEM programs, there has not been wide, systematic evaluation of the findings from these studies (Martin, et al., 2018). Therefore, the present aim is to perform a systematic review of the literature to evaluate the effectiveness of STEM programs available to undergraduate Hispanic students and whether they are leading to improved outcomes of STEM success or achievement.

This systematic review assesses four-year time to graduation in a STEM major as one of its target outcomes of interest. Previous systematic review work in this area has focused on two-year colleges (Martin, et al., 2018) and has not yet examined what occurs at the four-year institution level. Also, programs such as the McNair Scholars Program that focus on increasing representation of UREM in STEM are only available at four-year institutions. For these reasons, this systematic review looks at four-year time to graduation rates, post-graduation employment rates, and enrollment in graduate school programs (masters or doctorate).

In addition to the limited examination of STEM programs for undergraduate Hispanic students, we further assert that these evaluations should be more rigorous in their estimation of success outcomes. Measuring more specific factors such as graduation rates and post-graduate program entrance would more directly help researchers to address disparities in STEM degree attainment and representation in STEM fields (De Brey, et al., 2019; U.S. Department of Education, 2015). Investigating the effectiveness of these programs on these types of outcomes would also better inform policy and practices to support national STEM efforts. The in-depth evaluation provided by this systematic review can provide useful recommendations and directions for increasing Hispanic representation in STEM.

Systematic Reviews. More than a literature review, systematic reviews are a detailed form of research where a thorough protocol is used to develop a search strategy to assess the efficacy of interventions in a particular area (Uman, 2011). The goal is to synthesize findings, reduce bias, and assess quality of studies included to determine whether particular interventions work (2011). Systematic reviews are seen as a critical

research tool as they help to systematically assess what is already known about a particular topic and allow researchers to determine where to take future research next (Chalmers et al., 2014). While generally used in healthcare research, a systematic review is critical in this work as we want to identify what programs exist that target the underrepresentation of Hispanics in STEM. The systematic review will allow us to see what programs exist, whether they were effective, and which factors have been predominantly focused on in this work.

At the present moment, it appears only one systematic review exists that is similar in scope, illuminating the significant lack of research focused on Hispanic undergraduates' advancement in STEM. It specifically evaluates interventions such as mentoring, counseling, tutoring, undergraduate research, and transfer programs that support Latinx students majoring in a STEM field at two-year institutions (Martin, et al., 2018). While informative and did include some information on four-year graduation rates, the systematic review was limited in range. It focused on STEM majors at two-year institutions or transferring to four-year institutions, conducted searches in only three databases, and did not assess effectiveness of programs for which statistical effect sizes may have been available. That systematic review's findings indicate that there was no single type of intervention that was effective for Hispanic students at two-year institutions; rather, interventions had the potential to be impactful because of their added support for students beyond the basic degree offerings. The absence of another systematic review that measures the effectiveness of STEM interventions specifically for Hispanic undergraduate students is problematic. If researchers are attempting to implement programs as a viable aid in decreasing underrepresentation, then evidence should be

available to speak to their effectiveness. Toward this end, this systematic review sought to identify existing STEM programs and interventions supporting Hispanic students attending four-year universities, with a specific focus on their impact on a targeted four year time to graduation.

Methods

To examine empirically based literature examining the effectiveness of STEM interventions on Hispanic students' four-year graduation rate, a systematic review methodology was selected. The required Cochrane guidelines components are outlined below (Higgins et al., 2021).

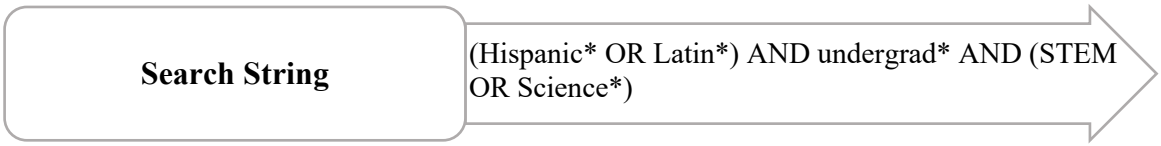
Criteria for considering studies for this review. For studies to be included in this review, the population must include or focus on Hispanic undergraduate students enrolled in a STEM degree at a four-year institution. The effectiveness of at least one STEM focused intervention must be examined by at least one of the following outcome measures: graduation rates, post-graduation employment rates, and enrollment in graduate school programs (Masters or PhD). The study must provide clear statistical evidence between a STEM focused intervention and one of the specified outcomes. Only quantitative studies were included because they can statistically assess effect sizes.

Studies were not included in the review if they did not have a population that included or focused on Hispanic undergraduate students enrolled in a STEM degree at a four-year institution. Studies were also ineligible if they did not evaluate the effectiveness of at least one STEM focused intervention on at least one of the outcomes of interest (graduation rates, post-graduation employment rates, and enrollment in graduate school programs [masters or doctorate]). If the study did not provide clear, statistical evidence

between a STEM focused intervention and one of the specified outcomes or was not a quantitative study, then it was excluded.

Figure 1

Key Search Terms and String



Search methods for identification of studies. The development of the search string (Figure 1) began with consultation of a librarian who specializes in systematic reviews at the university where this review was conducted. Once the search string was developed, the 45 databases were chosen based on relevance to the topic. One reviewer adapted and applied the same search string in all 45 databases (Table 1) for this review in March 2020.

Forty-five electronic databases were used by authors in the literature search. The searches were conducted by one author. There were no publication date, geographic location, or language restrictions. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) search flow diagram reflects the full search process (Moher et al., 2009; see Figure 2). Grey literature (e.g. dissertations, theses, conference proceedings, or conference abstracts) was included if relevant and indexed in the databases searched (Mahood et al., 2014; Saleh et al., 2014).

Table 1

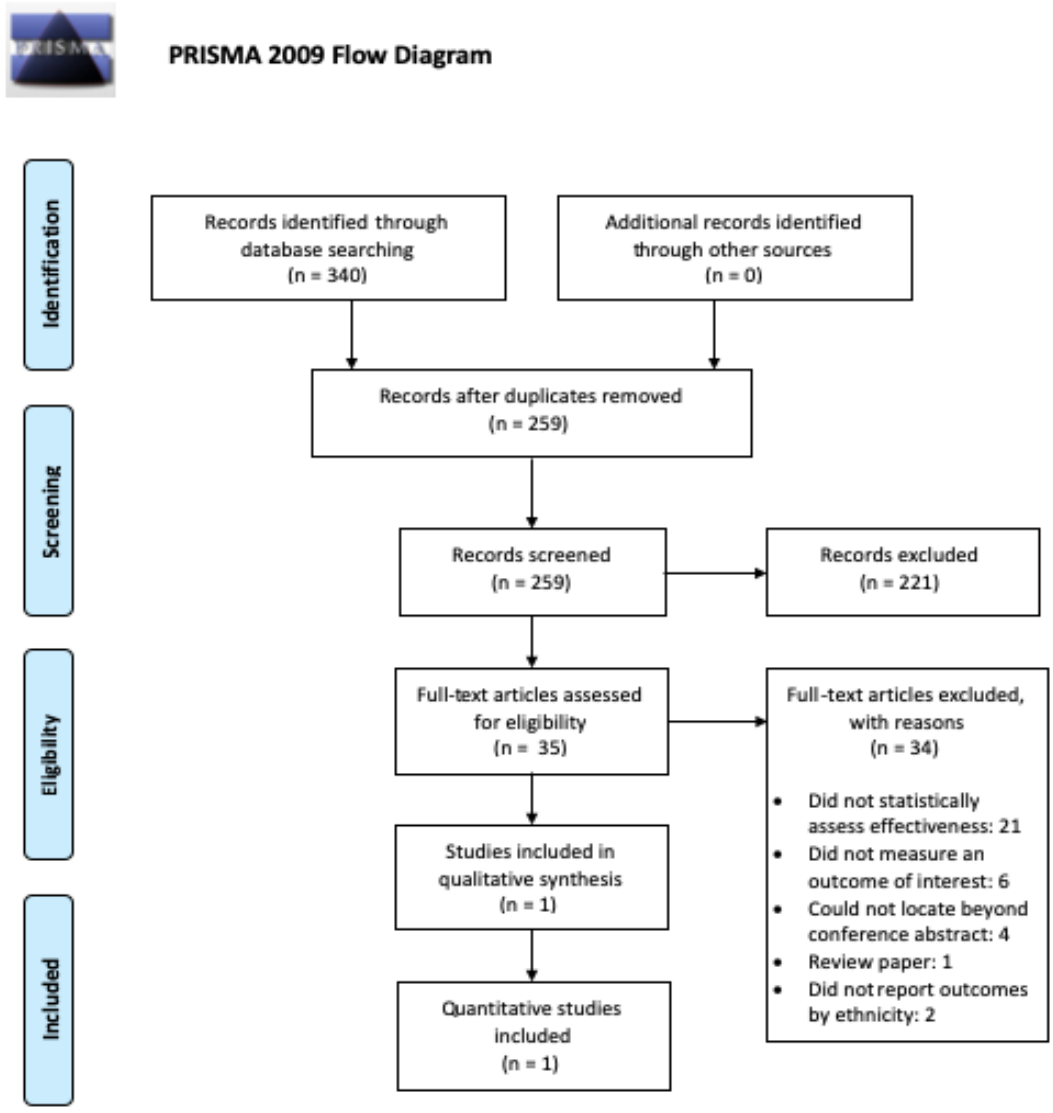
List of Databases Searched

Database	Number of Hits
Academic Search Complete	364
American Chemical Society	1,557
American Institute of Physics	702
American Mathematical Society	2
Applied Science and Technology Source	23
Article First	8
ASCE Library	188
ASME Digital Collections	0
ASSIA	3,307
ASTM SEDL- Digital Library	0
Biomed Central	477
Current Contents Connect	79
Diversity Studies	14
e-Duke Journals	0
Earth and Environment Databases	2
Education Source	260
Education Database	18,117
Educator's Reference Complete	6,060
eHRAF World Cultures	0
ERIC(EBSCO Host)	324
ERIC(Proquest)	317
Ethnic Newswatch	968
GeoREF	71
GreenFILE	2
GVRL: Social Science	126
IEEE/IET Electronic Library	58
INFORMS	80
Ingentaconnect	11
Inspec	286
IOP Science	40

Materials Business Files	338
Nature Online + Archive	3
NTIS Database	0
Oxford Journals	0
Project EUCLID	0
Proquest Biological Sciences	7,024
ProQuest Materials Science Collection	4,383
PsycArticles	24
PsychInfo	688
SciELO	53
Science in Context	739
Social Science Database	13,462
SSRN: Social Science Research	0
Web of Science Core Collection	207

Figure 2

PRISMA Study Flow Diagram



Data Analysis

One reviewer applied the selection criteria and exported to Refworks the selected studies from the 45 databases. Once the citations from Refworks were imported into Covidence, the duplicates were automatically removed. Two authors then independently performed title and abstract screening and independently applied the selection criteria during the full-text review phase. All disagreements at both the title and abstract screening and full-text review phases were discussed at length between the two authors.

Data extraction was conducted in Covidence by EB and CH. EB contacted authors of two full-text articles requesting necessary information for the data extraction phase. One author did not respond to the data request and another author initially responded but was unable to provide the information requested therefore resulting in the exclusion of both articles. The following information was extracted for the one study that met inclusion criteria: type of resource, general information (title, authors, year of publication), population information (Hispanic, undergraduates), study methods (quantitative), intervention type (At least one specific, STEM intervention focusing on addressing representation of Hispanic students in STEM), and outcomes (four-year graduation rates, post-graduation employment rates, or enrollment in graduate school programs).

Assessment of quality and risk of bias. To assess quality and risk of bias, the Effective Public Health Practice Project Quality Assessment tool for Quantitative studies (Thomas et al., 2004) was used. It is a standardized study quality assessment tool that rates studies on eight different sections: selection bias, study design, confounders,

blinding, data collection methods, withdrawals and dropouts, intervention integrity, and analysis. The rating scale classifies the components as 'strong', 'moderate', 'weak' and then these totals are used to identify the overall rating which is also classified as 'strong', 'moderate', or 'weak'. The tool itself includes a bias assessment, so a separate risk of bias was not employed based on recommendations that encourage the use of multidimensional quality assessments (Wells & Littell, 2009).

Results

In total, 59,747 studies were identified using the search string (Figure 1) across all 45 databases. After screening relevant titles by one reviewer, 340 citations were imported to Covidence. Covidence removed duplicate citations and two reviewers screened 259 articles, of which 221 articles were found to be irrelevant and excluded. This left 35 articles that were screened after reading the full-text of the articles (Table 2). In total, 34 full-text articles were excluded for not meeting inclusion criteria. Three articles were eligible based on the inclusion criteria. Two of these studies presented the Hispanic student data within the larger racial and ethnic minority students' results; this meant that it was not possible to examine the effectiveness of the intervention for Hispanic students specifically. To gather this additional data, as is suggested in systematic reviews (Pati & Lorusso, 2018; Robertson-Malt, 2014), authors of these two studies were contacted for additional data information specific to the Hispanic participants in their studies; neither provided the requested information. Subsequently, two articles were excluded (Robertson-Malt, 2014), and data extraction was conducted on the remaining article.

Table 2

Characteristics of Excluded Studies

Author and Year	Exclusion Reason
Abramowitz & Hamilton, 2019	Did not statistically assess effectiveness
Baron, 2016	Did not statistically assess effectiveness
Bingham et al., 2003	Did not statistically assess effectiveness
Blake et al., 2013	Did not statistically assess effectiveness
Bouniaev et al., 2014	Did not statistically assess effectiveness
Burkett et al., 2015	Did not statistically assess effectiveness
Della-Piana et al., 2003	Did not measure an outcome of interest
Gafney, 2010	Did not statistically assess effectiveness
Gates et al., 2011	Did not statistically assess effectiveness
Georgiopoulos et al., 2009	Did not measure an outcome of interest
Godreau et al., 2015	Review paper
Haacker-Santos et al., 2006	Could not locate beyond abstract
Harris et al., 2012	Did not statistically assess effectiveness
Hernandez et al., 2013	Did not measure an outcome of interest
Jin et al., 2019a	Could not locate beyond abstract
Jin et al., 2019b	Did not statistically assess effectiveness
Kang, 2011	Did not statistically assess effectiveness
Louzada & Abell, 2003	Could not locate beyond abstract
Louzada et al., 2008	Did not statistically assess effectiveness
McGonagle et al., 2014	Did not statistically assess effectiveness
Morley et al., 1998	Did not statistically assess effectiveness
Nandy et al., 2019	Did not statistically assess effectiveness
Piper & Krehbiel, 2015	Did not statistically assess effectiveness
Pullin & Majkowski, 2012	Could not locate beyond abstract
Pyrtle et al., 2008	Did not statistically assess effectiveness
Robinson et al., 2007	Did not statistically assess effectiveness
Salto et al., 2014	Did not measure an outcome of interest
Shuster et al., 2019	Did not measure an outcome of interest
Slovacek et al., 2012	Did not report outcomes by ethnicity
Thompson et al., 2019	Did not statistically assess effectiveness
Toven-Lindsey et al., 2015	Did not measure an outcome of interest
Whittinghill et al., 2019	Did not report outcomes by ethnicity
Wilson et al., 2012	Did not statistically assess effectiveness

Young et al., 2005	Did not statistically assess effectiveness

Two authors independently utilized the tool to assess the study that met inclusion criteria and identified a 'weak' overall rating for the study (Table 3). This overall rating was taken into consideration by authors when discussing the results of this systematic review. A forest plot was not created due to recommendations from Cochrane Group that advise against creating these plots with single studies.

Table 3

Detailed Summary

Author	Selection Bias	Study Design	Confounders	Blinding	Data Collection Method	Withdrawals and Dropouts	Global Rating
Vora et al., 2020	Weak	Moderate	Moderate	Moderate	Strong	Weak	Weak

Included Study

The one study (Vora et al., 2020) that met the inclusion criteria focused on Hispanic undergraduate students majoring in biomedical science (a STEM field) at a four-year university. The intervention entailed a course-based undergraduate research experience meant to engage more underrepresented minorities in research, particularly those in a biomedical science program. This study focused on a STEM intervention for Hispanic undergraduates majoring in STEM; utilized quantitative methodology on retrospective cohort data to compare undergraduates participating in the program to counterparts not in the program; and assessed the primary outcome of graduation rates.

It is important to note that this study did not measure the pre-established outcomes of post-graduation employment rates or enrollment in graduate school

programs (Masters and PhD). Rather, a multivariable logistic regression model was conducted comparing four-year graduation rates of those students participating in the Biomed sciences intervention to those of counterparts not participating but majoring in Biomed sciences. Due to the retrospective nature of the cohort study, only some longitudinal data were available for the comparison. The total sample size for participants with available data was 57 students: 25 in the non-participant group and 32 in the intervention group. The analysis reported in the study did not appear to find a significant effect of the intervention when comparing program participants to non-participants on four-year graduation rates (OR=1.71, 95% CI: 0.78, 3.74; Table 4).

Table 4

Summary of Findings

Outcomes	Relative effect (95% CI)	Number of Participants (Studies)	Quality of Evidence (EPHPP)	Comments
Four- year graduation rate	OR=1.71 (0.78, 3.74)	57 (1)	Weak	Authors only had outcome for a portion of the sample; Could not perform meta-analysis
Post-graduation employment rates				No studies were included that examined this outcome
Enrollment in graduate school programs (Masters and PhD)				No studies were included that examined this outcome

Discussion

At the present moment, this is the only systematic review currently examining the effectiveness of STEM interventions for Hispanic undergraduates at four-year

universities. This is part of the broader issue in lack of evaluation. Many STEM focused programs provide limited assessment information, especially for underrepresented groups (U.S. Government Accountability Office, 2018). Broadly, it is important to evaluate the effectiveness of STEM programs to better serve students, but even more so for UREM groups, especially Hispanic groups who hold less representation shares in the STEM workforce (Pew Research, 2018). Evaluation will help identify which aspects of programs work significantly and which do not, allowing for evidence-based restructuring to create truly effective programs so that commonly shared goals of increasing Hispanic and other UREM's participation are successful.

Despite the differences in the review by Martin and colleagues (2018) who focused on programs at two-year institutions and transfer students, the results from the present review align with their finding that very little literature is available on the effectiveness of these STEM programs for Hispanic undergraduates. As is seen in this review, only one study was eligible for inclusion. Despite the difference in population parameters (two-year vs four-year institutions), it appears that a similar gap in research exists.

One study (Vora et al., 2020) met the requirements for the present systematic review's goal of statistically assessing the effectiveness of STEM interventions for Hispanic undergraduates majoring in STEM at four-year universities. The study did not find a statistically significant intervention effect for four-year graduation rates—one of the primary outcomes intended to be evaluated by this review. It is challenging that only this study qualified for inclusion in this review, because it tells us that there is a lack of available literature on the effectiveness of these programs. It is also not possible to

conclude whether STEM intervention programs provide benefits to Hispanic undergraduates; they are not being sufficiently examined. These findings point to a need for increased effective evaluation of existing programs, with an emphasis on identifying outcomes specific to Hispanic students' experiences. Increasing understanding of Hispanic students' outcomes will provide points for addressing weaknesses in current intervention programs that may ignore the diverse experiences of Hispanic students. It also opens the possibility for improvements to these types of programs as through evaluation we would be better able to identify which aspects of these programs aid in increasing representation of Hispanic students in STEM.

Limitations

There are methodological concerns that should be addressed. The low specificity of the search string could have impacted the search results as it was intentionally left broad in order to capture more studies. The search string was also specific to Hispanic/Latinx ethnic groups and could have missed articles using UREM more broadly that then disaggregated by racial/ethnic groups in their analyses or articles using Chicano/a. The attempts to obtain relevant data from two authors were also not successful and resulted in the inclusion of only one study. These factors could have affected the overall completeness and applicability of the present review. Furthermore, the review only focused on specific long-term outcomes such as four-year graduation rates. This meant that studies on programs from two-year colleges were not included for review. An issue with long-term outcomes, unfortunately, is that they can be expensive and difficult to collect since it requires following participants over long periods of time. This can

affect the availability of long-term outcomes in instances when they may not be available yet if intervention programs are recent or just beginning.

Conclusions

The lack of evidence highlights a gap in evaluative research for measuring the programs' effectiveness at increasing representation of Hispanic undergraduates in STEM. The present review also identifies the need for methodological changes in the ways STEM interventions are being evaluated, as many potentially relevant studies did not conduct statistical assessments of effectiveness. Interventions must develop measurable assessments to illustrate how they are contributing to increasing Hispanic students' representation in STEM degrees.

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III. STUDY TWO: RESISTIR: HISPANIC UNDERGRADUATE STEM MAJORS' PERCEPTIONS OF BARRIERS AND SUPPORTS TOWARDS DEGREE PERSISTENCE

Abstract

Despite increases in STEM degree attainment of Hispanic students in recent years Hispanic groups continue to be underrepresented in STEM fields. We utilized qualitative content analysis methods to identify Hispanic STEM majors' perceptions of both supports and barriers in their STEM degree pathways. Two short answer questions exploring barriers and supports were asked of 947 Hispanic undergraduate STEM majors at a Hispanic Serving Institution (HSI) in the Southeastern region of the United States (U.S.). Our findings revealed interesting perspectives that illuminated the importance of financial access, family, teacher, and peer support, as well as acknowledgement for the role of experiences unique to Hispanic groups. We suggest further research into these specific themes that arose and that these findings illuminate the importance of respect and inclusion of Hispanic culture with regards to increasing Hispanic representation in STEM.

Keywords: STEM Persistence, STEM Success, Underrepresented Minorities, Hispanic, Undergraduates, Content Analysis

The United States Science, Technology, Engineering, and Mathematics (STEM) workforce grew 79% from 1990 to 2018 (Pew Research, 2018). Pew Research Center (2018) finds that people with a college degree in STEM also earn more in annual income than non-STEM majors, regardless of working in a STEM field. Clearly, there are distinct advantages to earning STEM degrees. However, minorities continue to be largely underrepresented in STEM despite increased racial and ethnic diversification of the field over the last approximately 25 years (Funk & Parker, 2018). This gap is particularly evident for Black and Hispanic groups. In 1990, the STEM workforce was 7% Black and 4% Hispanic (Funk & Parker, 2018). As of 2018, those numbers have increased to 9% and 7%, respectively, with Hispanic groups making the smallest gains (Funk & Parker). Although Hispanics are the fastest growing minority population in college campuses today, only 15% of Hispanic students were awarded a STEM bachelor's degree in the 2015-16 school year (De Brey, et al., 2019). A response to this is increasing STEM education funding through federal agencies. However, investment in these programs was relatively the same from 2010 to 2016 (United States Government Accountability Office [GAO], 2018). A GAO report (2018), also found STEM education program availability decreased by 22% between 2010 and 2016.

Several studies have sought to identify why Hispanics are not entering STEM degree programs in greater numbers. It has been consistently found in Hispanic college students' persistence toward degree completion research that prioritizing working over attending or primarily focusing on college education is a reality for many Hispanic students in the U.S (Kelly et al., 2010; Whalen & Shelly, 2010). Economic barriers not only affect Hispanic college students' ability to attend school, but can also slow

time-to-completion among those who persist through their degree (Aschbacher et al., 2009; Nora & Crisp, 2012; Sy & Romero, 2008). These economic barriers also limit Hispanic students' engagement in science courses and programs. Research finds that long-term program retention and graduation for minorities and women is predicted significantly by financial need and aid (e.g. work-study, loan, and gift; Castleman et al., 2018; Whalen & Shelly, 2010). This makes participating in a research laboratory, STEM support programs, and other opportunities that are critical to success in STEM fields more difficult (Myers et al., 2011; Tyson et al., 2007). Further, it is common for students to have completed a STEM degree and not have been taught or supervised by an underrepresented ethnic minority (UREM) professor (Nelson et al., 2007). This insinuates that many UREM students may not have access to seeing people like them in the careers they potentially aspire to.

Research has also taken the perspective of examining which factors provide support for Hispanic undergraduates to be successful in STEM. One of the major focuses of this work is on role models. Research on role models has found that Hispanics often regard family members as role models, as well as faculty and staff in their educational pursuits (Preuss et al., 2020). Research has also found that access to role models with ties to STEM has been connected to increasing minority students' persistence in science fields and having positive effects on their self-esteem and affinity with the field (Nelson et al., 2007; Seymour & Hewitt 1997). Hispanic students have noted that mentorship and family play key roles in their education and success (Foltz et al., 2014; Lozano et al., 2018; Peralta et al., 2013). Another important, supportive factor to note is that Hispanic Serving Institutions (HSIs) have been implicated in being supportive of Hispanic

students' general educational pursuits (Dayton et al., 2004; Nora & Crisp, 2012) as well as those pursuits relating specifically to STEM interests.

It is useful to consider the impact of attending a school with large numbers of minority students, particularly those designated as HSIs. Defined as not-for-profit institutions with an enrollment of at least 25% self-identifying Hispanic students (Hispanic Association of Colleges and Universities, n.d.), there is a growing interest in the relevance of HSIs in addressing disparities in STEM degree entry and persistence for Hispanic students. HSIs were responsible for 40% of the STEM bachelor's degrees awarded to Hispanic students in 2010 (Núñez, et al., 2015). It has been asserted these institutions are able to better provide opportunities to have peers, services, and other culturally specific identifiers integrated across Hispanic students' college experiences, all factors associated with greater academic success (Crisp et al., 2009; Eagan et al., 2010; Irizarry & Donaldson, 2012; Williams & George-Jackson, 2014).

However, very few studies examine the issue of underrepresentation from the lens of Hispanic students themselves. In fact, no qualitative studies to date have specifically examined these issues across the many disciplines in STEM and used such a large scale sample of Hispanic students. Hispanic STEM students' perceptions of the factors that serve to hinder or support their degree, persistence, and attainment are important because of increased focus on mitigating underrepresentation for this population. In order to make effective change, we need to examine large scale samples across the different majors to understand how these various spaces affect Hispanic STEM majors' perceptions of their barriers and supports

Current Study. It is important to gather perspectives about STEM persistence motivators and influences from large, diverse groups of Hispanic students. While large scale surveys can provide a big picture lens of generalized experiences within this population, they cannot capture the nuanced, unique, and culturally specific perceptions from respondents. Further, although smaller sample sized qualitative studies provide intimate insights, they lack generalizability and broad scopes of variability in a population. Very few studies examine the issue of underrepresentation from the lens of Hispanic students themselves. The present study aims to address these methodological voids while centering the voices of Hispanic undergraduate STEM majors attending a large HSI to identify the most common barriers and supports to succeeding in STEM degree attainment. Using content analysis approaches, we can analyze a larger sample of written responses than is generally analyzed. This approach makes it more feasible to analyze all the responses this population gave describing the barriers and supports most salient to their ability to persist and succeed in STEM degree attainment.

Methods

Author Positionalities. The first author is a cisgender, Hispanic woman of Puerto Rican descent. She has lived all of her life in Miami. As a Hispanic woman in STEM herself, her experiences have led to studying and understanding how exactly Hispanic students succeed and persist through STEM pipelines. Utilizing her position as a doctoral student, she has investigated how the intersection of ethnicity and context shape the experiences of other Hispanic students in STEM.

The second author is a cisgender, Black woman of Canadian-Caribbean descent. She has lived half of her life in the United States. An Associate Professor of Psychology

with training in Women's and Ethnic studies, her work has focused on racial, ethnic and gender identity development within populations of color.

Protection of Vulnerable Populations. In order to protect the sample of students utilized in the present study, researchers did not collect names with responses and de-identified any potentially identifying information provided in their responses. Researchers also provided participants with information on how to access on-campus counseling services in the event they wanted to discuss their experiences further.

Data Collection. These data were collected as part of a larger quantitative study examining how Hispanic undergraduates persist and succeed in STEM. The students attended a large HSI located in the Southeastern region of the United States (U.S.) that has an undergraduate population of approximately 55,681 students; 64.73% self-identify as Hispanic/Latino, 11.95% Black/African American, 10.51% white/Caucasian, and 2.66% Asian[2].

Participants were recruited from 38 courses spanning biology, chemistry, engineering, computer science, math, and psychology that were available at the university during the summer semester. The second author emailed all faculty who were teaching STEM courses during the summer semester to see if they were willing to have their students participate. Those that responded during that three-month period were provided a unique Qualtrics link that they would post in their course's online shell platform. Prior to beginning the survey, participants completed an online consent form. This would direct students to the full survey, including the short answer questions examined in this study.

[2] We recognize that the most appropriate classification of groups with Asian ancestry are best referred to by specific nation or regional origin (American Psychological Association, 2020). However, this percentage was retrieved from institutional data that does not provide this information. Therefore, we have reported students with Asian ancestry as 'Asian' in keeping with the language of the available institutional data.

After completing the online survey and short answer question, the participants were asked to navigate to a separate Qualtrics link to provide their information to receive extra credit participation points at the professors' discretion.

Two short answer, write-in, open-ended questions in this survey are being analyzed in this study: 1) "Why do you think so few Hispanics pursue STEM careers? Please share your own experiences.", and 2) "Who initially encouraged your STEM interests? Who may have not supported your STEM interests?". Both questions were intentionally left broad to capture as much variability in responses as possible. Participants were not given a word or time limit and were free to share as much or as little as they felt comfortable with. Additionally, the survey allowed the option to continue without providing a response in the event that participants did not feel comfortable providing an answer at all.

A total of 704 Hispanic undergraduate STEM major participants answered the barriers related question (men= 286, women= 418) and 839 responded to the support related question specific to this study (74.3% and 88.6%, respectively, of total participants; men= 370, women= 469). Reported familial nations of origin included Cuban, (37.17%), American (18.16%), Venezuelan (7.18%), Colombian (5.91%), and others (see Table 1). All identifiers were removed from the assignments prior to coding, thereby disassociating any connection between the responses and students. Hence, there was no way to link responses back to individual students.

Table 1

Hispanic Familial Nations of Origin

Country	Total	%
Cuba		
USA	352	37.17%
Venezuela	172	18.16%
Colombia	68	7.18%
Nicaragua	56	5.91%
Peru	38	4.01%
Puerto Rico	31	3.27%
Dominican Republic	31	3.27%
Spain	30	3.17%
Honduras	28	2.96%
Argentina	19	2.01%
Brazil	15	1.58%
Mexico	15	1.58%
Ecuador	13	1.31%
19 other nations	12	1.27%
Did not specify	43	4.62%
	24	2.53%

Data Analysis. Due to the large number of provided responses, the content analysis qualitative research technique was utilized. Specifically, a conventional content analysis was used, whereby coding categories are derived directly from the data. The choice to conduct a conventional content analysis allowed researchers to examine such a large amount of responses in a shorter time frame by coding the short answer responses with meaningful categories and using codes derived from the responses themselves instead of totaling specific word usage (Calamidas & Crowell, 2018; Weber, 1990).

Researchers created a working coding-scheme based on the common themes and patterns derived from reading the responses and did not use 'preconceived categories' (Kondracki & Wellman, 2002). This method involves researchers immersing themselves in the data because in order to develop categories and codes, data must be continually read and discussed to understand participant perspectives (Kondracki & Wellman, 2002; Tesch, 1990).

For the current study, the code book began with focuses on two open-ended questions coded. The PIs first read a subset of 95 responses to begin to identify potential themes available in the data. They met to compare themes they had identified to ensure that no key themes or patterns had been missed. From there, four broad themes emerged and together they reached consensus in identifying sub-codes within each theme to address patterns in responses; ongoing discussions were held to ensure they shared the same identification process and code definitions were clear. The development of codes was consistently an iterative process with researchers meeting regularly to discuss removal, expansion, and use of the codes. These approaches of coding-recoding and researcher discussions were taken in order to increase trustworthiness as it relates to accurately representing the data (credibility) and quality of the data analysis (dependability; Kyngäs et al., 2020; Lincoln & Guba, 1985).

Once the coding scheme was established, two researchers coded all the participant's responses using the codebook developed by the authors. It is important to note that responses were detailed and could cover a variety of categories. Therefore, more than one code could be applied to one response. Participants' responses were listed in an Excel sheet that included a unique participant ID, major, and gender. The codes were

entered into Qualtrics using group rank formatting, allowing the codes to be organized by category. The codes included their subcategory, code name, and definition from the codebook established by the researchers. This allowed researchers to drag and drop the relevant codes by category for each unique response, ultimately resulting in an excel sheet that included their unique participant ID, gender, and applied codes. To assess the reliability of the coding process and codes, two researchers coded 10% of the responses using the codebooks; their interrater reliability was greater than 80% and Cohen's κ revealed substantial reliability ($\kappa > .6$) for the codes (Landis & Koch, 1977; O'Connor & Joffe, 2020; O'Connor & McNicholas, 2020).

Code frequency analysis was conducted in RStudio. Utilizing code that identifies the number of occurrences of a string in a column of data, researchers were able to extract how many times each code label was applied across responses. This information was then organized into table format. This code frequency analysis method was also used to extract how many times a theme was seen in the four broader code categories that were re-examined after applying codes.

Results

A broad goal of this study was to identify factors that contributed to Hispanic ability to pursue and complete STEM degrees. For this reason, respondents' views about assertions that Hispanics are underrepresented in STEM is important to consider. Approximately 10% of participants' statements indicated they did not view Hispanics as being underrepresented in STEM; another 11.2% asserted that they were not aware that Hispanics were perceived as being underrepresented. These students, who represented 20% of the sample, pointed to their classmates and other individuals they knew as

examples that challenged the perception that Hispanics were not numerically significant in these fields.

> "I didn't know few Hispanics pursued STEM. All my close relatives pursued careers in STEM, and I have Hispanic friends who also pursued STEM degrees. However, I also live in [study city], so I am sure that affects my perception of Hispanics in STEM."

> "I don't think this statement is true. A lot of Hispanics pursue a STEM career"

Relatedly, only 14 students' comments specifically acknowledged that their experience with having several Hispanic colleagues and role models in STEM was unique specifically because they were attending a HSI located in a predominately Hispanic city. Few students noted that STEM majors sharing the same ethnic identity attending other institutions or living in other regions would have different perspectives.

> "Overall, there might not be many Hispanics who pursue STEM careers. However since [HSI name] has a very large Hispanic community I have seen many Hispanics."

Despite this finding, all participants shared their perceptions of what factors were barriers and supports in their pursuit of STEM degrees. Overwhelmingly, financial and familial influences were the most salient influences on these students' experiences; these factors emerged as both barriers and supports in responses. The nuanced meanings informing results are presented below.

Sources of Barriers

In total, four thematic codes emerged as salient barriers for Hispanic STEM majors in pursuit of their degree:1) Hispanic cultural barriers, 2) financial, 3) STEM field

culture, and 4) family (see Table 2). Respondents were generally detailed in describing the specific barriers they faced, with the most prominent reported and discussed below.

Table 2

Sources of Barriers Coding Definitions and Frequencies

Code	Definition Examples	Total	%
Hispanic Cultural Barriers	Factors associated with being Hispanic or Hispanic cultural cues	**217**	**30.82%**
Language barriers	Can inhibit participation because of demands to learn/speak English	65	9.23%
Social Justice Degree goals	A preference for fields where they can have a social, political and economic impact on Hispanic communities well being	52	7.38%
Ethnic Discrimination	Experiencing discrimination or bias for being Hispanic in STEM	57	8.09%
Immigration status	Immigration status affects factors such as STEM education attainment or job attainment; Talking about advantages/disadvantages of being born in the US and how that affects STEM success	43	6.11%
Financial Barriers	Monetary related reasons for not being able to access college, STEM experiences, etc.	**148**	**21.02%**
STEM Field Culture	Factors associated with operating in STEM programs and the culture of the field	**135**	**19.18%**
Difficulty of STEM	Stating the difficulty or challenging nature of STEM fields is a deterrent	75	10.65%
High time commitment	STEM degrees involve a lot of time or more time than other fields and might mention this is why some may opt for a different/shorter type of career; could be referring to years in school or study time	60	8.52%
Family	Contributing to family in some way that is not financial or needing to work themselves to pay for school as a reason for pursuing or not STEM careers	**43**	**6.11%**

Hispanic Cultural Barriers. Factors associated with being Hispanic or Hispanic cultural cues were used to determine what barriers existed under this category. A total of four subthemes related to barriers participants perceived as being associated with Hispanic culture, including language, discrimination, social justice degree goals, and immigration status.

Language Barriers. A commonly mentioned concern by participants was the ability to learn, use, and understand English language in STEM classes when their first language was Spanish. These difficulties with language barriers were seen as preventing many students from being able to pursue the more difficult subjects needed to learn and understand STEM.

> "It's really hard when you don't speak the language, it can make the class harder."

Participants also noted the difficulty and lack of resources available for learning the English language. In addition, some first-generation participants mentioned they lacked access to education related resources because their parents could not understand English materials when they first immigrated to the U.S.

Ethnic Discrimination. Discrimination due to identifying as Hispanic was reported as a barrier to persisting and succeeding in STEM. Several participants made statements indicating that Hispanic students often were made to feel incapable of succeeding in STEM primarily because of their ethnicity. Other participants asserted that racist ideals were prevalent in higher levels of STEM, and this led to discriminatory experiences. Overall, any form of discrimination was reported as being a deterrent and factor that contributed to limiting participants' success toward completing their STEM degree.

> "I believe Hispanics are posed with the stigma of being a minority and are challenged and looked down upon due to that."

Social Justice Degree Goals. Another commonly discussed factor for the low rates of Hispanics in STEM was the assertion that many Hispanic students were seeking degrees that aligned with their personal interests with Latin America, immigration or other related socio-political factors. Fifty-two participants related the underrepresentation to interests in other fields such as politics or disinterest in STEM subjects when compared to social justice related areas.

> "Because they feel like they would make a greater impact in the liberal arts since most immigrants leave their country because of oppression and feel a tendency to fight against that by pursuing a career in the liberal arts and not in STEM."

Immigration Status. Several participants brought up issues relating to immigration status and the complexities of coming from different countries to the U.S. Prevalent in many of the responses were the differences of immigrating to the U.S versus being born in the U.S to immigrant parents. This immigration reality was linked to financial stability, language barriers, and access to resources that could help with degree completion.

> "Many Hispanics born here have immigrant parents who work hard to send them to school or who cannot afford it. I am one of them—my parents work very hard so I can study. If the Hispanics aren't born in the U.S., it is harder due to the fact they need to be citizens or residents. And there could be issues with the language barrier."

Financial. Overall, the most frequently acknowledged barrier students reported for succeeding and persisting in STEM were financial concerns (*n*=148). This financial concerns parent code captured the primary monetary reasons that contributed to participants' perceived barriers to STEM degree entry and completion. Subcodes that emerged from financial concerns included the inability to currently afford schooling for a STEM degree (*n*=50) and relatedly, the higher cost of continuing to pursue advanced STEM degrees (*n*=27). This included the costs of tuition, living expenses while pursuing full-time degrees, and basic educational resources (e.g. books, school fees). One student shared their concerns on taking on debt and paying off student loans that would be required for later for pursuing higher level STEM degrees or careers.

> "Most come from low income households, who might not have the resources to fund a career in STEM."

Building upon this was the acknowledgement that to be successful in STEM, students need to participate in extracurricular training activities (e.g. labs, summer training programs, extra tutoring). The cost to access training or to take opportunities in lieu of working in paid positions was a key financial and academic stressor; many noted that negotiating this was difficult given how critical additional training was to their ability to move through the academic pipeline.

> "Many Hispanics do not have the resources like the time and money for something as exhausting as medicine or math which may require tutoring and a lot of support."

STEM Field Culture. A recurring theme in the responses was related to the cultures that are seen in STEM fields. Students frequently commented on the difficulties of STEM fields as well as how time-intensive they could be. These are important to explore as they could present deterrents for Hispanic students pursuing STEM.

Level of Difficulty. Participants (*n*=75) mention that the difficult nature of STEM fields can be particularly deterring, but were often not specific as to which part or parts they found to be particularly difficult. Responses consisted of a general consensus that students simply found the field to be difficult.

> "I think because it's known to be very hard."

High-Time Commitment. Many participants (*n*=60) also discussed the high-time commitments that are generally required by STEM fields. Participants often mentioned that time spent studying was generally more demanding than other fields. They also frequently brought up that STEM majors tend to be lengthy careers that require graduate schooling in addition to completing an undergraduate graduate. One participant wrote that the time commitments intersecting with other responsibilities can result in stress:

> "…STEM courses are manageable but they require a lot of time and effort, this can become extremely stressful alongside the pressure of having to bring some sort of income home..."

Family. When asked about barriers facing Hispanic students, the role of and obligations to family units were often brought up. As a frequently explored factor in these areas of research, it was important to examine student perspectives on the influence that family has in their pursuit of STEM.

Ability to Help Family or Themselves. Student responses often made references to familial obligations that made the pursuit of STEM fields potentially more challenging (*n*=43). Several mentioned that helping their families involved having to get a job to be able to pay for school, making it more difficult to find time to study.

> "…Family is such an important factor in our lives that for some they don't have the time or money to undergo these programs because they might have to take care of their families (or other situations come up)."

Sources of Support

In contrast to their answers about barriers, participants gave brief, less detailed responses about sources of support (see Table 3). Their answers to the questions "Who initially encouraged your STEM interests? Who may have not supported your STEM interests?" were significantly shorter and participants did not discuss who may not have supported them. In fact, 135 participants reported they had not encountered anyone who had discouraged their success or pursuit of a STEM career. An additional 48 participants did not cite anyone for being specifically involved in supporting their STEM efforts.

Table 3

Sources of Support Coding Definitions and Frequencies

Code	Definition Examples	Total	%
Family Related		**503**	**59.95%**
Family in STEM	A parent or other family members that might have a STEM career (e.g. grandparents, siblings, family friends)	98	11.68%
Family support pursuit of STEM	Family supports pursuing STEM or supports a STEM path that is different to the one the respondent hopes to pursue or is pursuing	405	48.27%
Self-motivated	Citing oneself as the source of encouragement for succeeding or a like or interest in STEM from a young age.	**195**	**23.24%**
Teachers	Broadly cites teachers for role in STEM or general education interests	**114**	**13.58%**
Peers	Friends, classmates, coworkers that specifically support pursuing STEM	**91**	**10.45%**

Family Related. Family again emerged as an important theme. However, it was particularly salient as a source of support for Hispanic STEM majors. The ways in which familial support emerged as most meaningful was in two distinct ways: having family members already in the fields or familial encouragement of STEM degree pursuits.

*Family in STEM***.** Several participants (*n*=98) indicated they had supportive family members with STEM careers. However, it is important to note that the majority of these participants reported that it was their parents, siblings, or grandparents who had careers in STEM.

> "My parents both hold bachelor's in STEM fields. My dad graduated from nuclear physics and my mom as a computer science and math major. They have educated me about how the world works since I can remember and have always encouraged me towards studying STEM..."

Family Support Pursuit of STEM. Overwhelmingly, 405 participants mentioned that their family overall supported their pursuit of STEM. Only 33 participants said that their family was not supportive or supported a different STEM career path than the one the student wanted to pursue.

> "My mom, we used to catch butterflies together, and do little science experiments."

Self-Motivation. Although the majority of participants reported that they received support from individuals in their social networks, a significant amount said they were their own source of support. Whether due to their own curiosities or success in learning math and science materials, many credit their success as being an outcome of their own self-encouragement.

> "Myself, I have always had an interest in computers from an early age."

Interestingly, when asked about barriers, 41 participants mentioned that perhaps, Hispanic students did not succeed and persist in STEM because they did not possess self-confidence. Other participants suggested that Hispanic students not receiving support or encouragement from family, peers, or teachers, was potentially a deterrent from pursuing STEM.

Teachers. Teachers also emerged as key figures in providing emotional support to these students pursuing STEM degrees. This included educators across the academic

pipeline as few respondents made differentiation in terms of their grade/ class standing or titled (e.g. professor or adjunct). In total, 114 participants broadly cited teachers as being supportive to students throughout their educational careers. Many saw this as a reason that allowed them to pursue STEM because they broadly received the encouragement and support they needed to reach educational goals, regardless of subject.

> "…Encouragement came mainly from teachers and professors I've had over the years, ranging from elementary to college..."

Several participants specifically mentioned teachers in STEM subjects that had encouraged and nurtured their interests in STEM. Many even cited specific professors that had encouraged them at the university level. This is important to note that encouragement coming from STEM educators at all stages of the educational pipeline are important to Hispanic students pursuing STEM.

> "My interests in science and technology were encouraged by a middle school teacher. He had more faith in me than I may have had in myself. It was important to know that someone I respected, genuinely believed in me."

Peers. The final significant source of support that emerged from the data were friends and close classmates. Participants (*n*=91) also frequently mentioned the encouragement they received from friends, classmates, and coworkers to pursue and continue working toward their STEM degree.

> "My family didn't support me entering STEM as they wanted me to go for a trade or a business degree. I was supported by my closest friends."

Discussion

The results of the content analysis provide valuable insight into what Hispanic undergraduates see as the most relevant barriers and supports when it comes to persisting and succeeding in STEM. These identified barriers and supports were related to three major factors involving cultural shifts, resources, and social and interpersonal factors. While these factors are often studied in the literature surrounding Hispanic undergraduates in STEM, our sample of students uncovered interesting differences in how they view barriers and supports.

The most widely discussed factor across responses related to experiences specific to "being Hispanic". This highlights the need for culturally specific and culturally responsive programming that integrates or acknowledges the diverse experiences within and across UREM populations. For several Hispanic undergraduates in this study, issues with language barriers and differing immigration statuses shaped their experiences pursuing STEM degrees. Relatedly, the inclusion of cultural differences could also help to decolonize the field by addressing discrimination and STEM field culture which centers Western, educated, industrialized, rich, and democratic (WEIRD) values (Henrich et al., 2010). This would address the issues related to STEM not providing applicable tools for addressing social justice concerns. Specifically, many in the sample believed STEM did not possess the social justice lens many Hispanic students pursue due to political conflicts found in their home countries. Acknowledging and welcoming diverse cultural differences allows for more open options that go beyond the traditional lens of long hours away from family and years in school. It is also an opportunity for designated

HSIs to refine an identity beyond simply enrolling Hispanic students and, instead, serving them (Garcia, 2017; Gomez et al., 2018).

Another significant finding was the salience of short- and long-term financial concerns for students' decision to pursue STEM degrees and continue into related careers. These participants were predominantly concerned with the immediate need to pay for school, paying for support resources (e.g. tutoring, research opportunities) and the ability to secure positions upon graduation to cover these related costs (e.g. loan repayment; Whalen & Shelly, 2010). This also aligned with the concern about STEM fields requiring a significant time commitment; these participants asserted that the time to degree or years of study required to enter a STEM career was a deterrent. Interventions and support programs should be exploring more of the direct financial needs of their Hispanic students to better understand how these programs can support those needs over the long term. Increased awareness of STEM-career-related loan-repayment programs early in the academic pipeline may address some of these issues. Studies have noted that when medical students were made aware of relevant loan repayment options, it increased their perceptions of research as a more viable career option (Driessen et al., 2020; Youngclaus et al., 2013) Providing smaller funding mechanisms for Hispanic students interested in STEM that allow them to access tutoring at different levels of education and research experiences could also potentially provide a different avenue of support.

Although there is limited research specific to the influence of families on Hispanic students' STEM degree success, these findings support some patterns in general research on their importance for undergraduate degree success for Hispanic students. These students overwhelmingly cited family as being an integral support of their STEM

pursuits, which aligns with previous research findings that show supportive Hispanic families have positive effects on students' educational success (Lozano et al., 2018; Peralta et al., 2013; San Miguel & Kim, 2015). However, the centrality of family can also make pursuing degrees more stressful as some students acknowledged being obligated to contribute to the family's expenses or provide support to family members in non-financial ways; these require making sacrifices in their STEM degree pursuits. This is in line with literature that finds Hispanic students less likely to move away from home for college because it involves leaving their families, creating added financial burdens or voids in support (Sy & Romero, 2008). Given that over 80% of the participants in this study reported that they lived at home or with family members, it is important that future research not simply consider familial support as a single construct, but identify ways in which Hispanic STEM majors willingly negotiate familial obligations simultaneously.

The self-motivation of Hispanic STEM students must also be considered given its significance in this study. Prior research has shown self-concepts and motivation with regards to STEM to have complex relations. In some research with undergraduate women, for example, positive relations exist between self-concept and motivation to study STEM for those in STEM subjects with low numbers of women, but this was not related for those in STEM subjects with a moderate representation of women (Luttenberger et al., 2019). However, with high school students, we do see positive relations between motivation and STEM career interests (Robnett & Leaper, 2013). Clearly, there is much more work to be done in these areas as it appears that the relations between self-concepts and motivations for STEM are mixed. Therefore, it could be important to examine this within

populations or contexts that are predominantly Hispanic where the intersecting role of family and other supports with self-motivation could also hold influence.

Students also reported teachers played an important role in their pursuit of STEM degrees via encouragement and support throughout their academic journey. This supports prior research that found teachers play important roles in modeling behavior and increasing STEM interests for UREM students (Hutton, 2019; San Miguel & Kim, 2015; Weber, 2011). Similarly, teachers' mentorship experiences have been found to shape for UREM undergraduate students' science identity (Estrada, 2018; Robnett et al., 2018). Given the perceptions of STEM culture as a barrier in terms of the field being difficult, teachers and their mentorship activities could play an important role in addressing this through their power and position in this context.

Several students touched on the role of peers in their STEM pursuits. Research with high school students has shown that peers supportive of STEM, increased motivation and self-concept for STEM careers (Robnett & Leaper, 2013). Research on STEM learning communities for UREM undergraduates finds positive relations between these peer focused contexts and STEM outcomes (Dagley et al., 2016; Freeman et al., 2008). It could be important to explore in Hispanic undergraduates as many saw peers as central to their support systems.

Limitations. There are some limitations to the study that must be considered, including those related to the population of interest. In the present study, our participants represent a very specific population of Hispanic STEM majors in several ways. First, this sample of participants identified primarily as Cuban, American, Venezuelan, and Colombian with most having lived the majority of their lives in the United States.

Drawing upon prior HSI research, it is highly plausible that the findings would differ if the sample included populations from different regions of the United States (e.g. California or Texas; Núñez & Elizondo, 2015, Chapter 4). Another unique factor about this sample is the geographic location of their school. These emerging adult Hispanic students all attend an institution located in an urban center where the majority of the residents self-identify as Hispanic (70%; U.S Census, n.d.). Similarly, over 70% of the students at this university identify as Hispanic (NCES, 2018). Essentially, these students were primarily interacting in contexts where Hispanics were not only the majority, but also more likely to hold large numbers of leadership positions across various settings, including STEM related positions. These culturally aligned environments are not the reality for the majority of Hispanic college students in the United States. Prior research has found that students in other regions of the country report low visibility of faculty, staff, or peers who are from racial/ ethnic minority groups (Gomez et al., 2018). Further, they continue to face higher levels of discrimination in the labor market (Pew Research, 2018). Thus, these student's differing perceptions of Hispanic representation and achievement in STEM can be potentially attributed to regional differences. These findings speak to the needs of a unique population of Hispanic students and cannot be generalized to all Hispanic undergraduate students pursuing STEM paths.

Responses were also not looked at by specific STEM major. It is possible that different STEM majors encounter contrasting experiences within their respective STEM field. Future work should consider examining these potential differences in perceptions between fields more closely.

There are also some methodological limitations that must be considered. The wording of the support question is retrospective in that it asks participants who initially encouraged their STEM interests. While several responses did cite current supports, it is possible that other participants focused on past encouragement and did not report examples of current support or encouragement.

While conventional content analyses are excellent for deriving information from participants' lived experiences, it is possible to miss identifying key categories that could influence the meaning of findings (Hsieh & Shannon, 2005). However, engaging in trustworthiness activities such as debriefing and member checks can help mitigate this (Hsieh & Shannon, 2005; Kyngäs et al., 2020; Lincoln & Guba, 1985).

Another challenge for conventional content analysis is that it is limited for use with theoretical development and very refined understandings of participants' lived experiences (Hsieh & Shannon, 2005). It is most appropriate for studies such as this one where the goal was to explore the lived experiences of Hispanic undergraduates, but without imposing too much inference on the relationships between some of the barriers and supports that were detailed.

Conclusions. Despite these limitations, this study provides foundational information about Hispanic college students perceptions of supports and barriers toward degree attainment. These insights are important for researchers, educators, and policymakers to explore as a 'one size' approach to the issues of underrepresentation in STEM cannot be used with Hispanic undergraduate students. The findings from this work show that there are within group differences when it comes to which supports and barriers are more prevalent for these students. Exploring the needs of Hispanic

undergraduate students in STEM with attention to the context in which they navigate, can be used to improve conditions and environments at all levels of the STEM academic pipeline.

IV. STUDY THREE: INSISTIR: HISPANIC CULTURAL VALUES' INFLUENCE ON UNDERGRADUATE STUDENTS' STEM IDENTITY AND PIPELINE PERSISTENCE

Abstract

This study seeks to address these voids in the literature by examining how cultural factors influence Hispanic undergraduates' perception of themselves and career aspirations using the integrative theoretical models of Relational Developmental Systems Theory (RDST) and Relational Cultural Theory (RCT). Hispanic STEM majors (age 18–29; n = 947) completed questions capturing their ethnic identity, *familismo* beliefs, career aspirations, STEM retention, and STEM identity. Measures were administered via Qualtrics. Model relationships were significant and positive for both Hispanic men and women, however, these models differed in strength of relationships. Specifically, the Hispanic women saw stronger positive associations than Hispanic men between culture, and STEM retention and STEM identity. However, Hispanic men saw stronger positive associations than Hispanic women between culture and career aspirations. Empirical findings support extending the quantitative work done on Hispanic underrepresentation in STEM to more often include examinations of cultural influences.

Keywords: STEM Persistence, Culture, Hispanic Undergraduates, Familismo, STEM Identity, STEM Retention

Minority representation across STEM fields is disproportionate to that of minority populations in the United States (U.S). While minorities make up approximately 30% of the U.S population, racial/ethnic minority groups continue to be underrepresented across most STEM job clusters (Pew Research, 2018). These concerns are especially relevant for Hispanic groups who only make up about 7% of the U.S STEM workforce, but represent 18% of the U.S population (Funk & Parker, 2018; Noe-Bustamante et al., 2020). Over the last approximately 25 years, Hispanic groups have made the smallest gains in STEM workforce representation despite the growth of the STEM workforce by 79% from 1990 to 2018 (Funk & Parker, 2018). This is also regardless of Hispanics being the fastest growing minority population on college campuses today. As of the 2015-2016 school year, only 15% of Hispanic students were awarded a Bachelor's degree in one of the STEM fields (De Brey, et al., 2019). With only 2% of Hispanic women and 4% of Hispanic men working in occupations related to the sciences or engineering (National Science Foundation, 2017), we must look to more holistic explanations for why this group is so underrepresented in an increasingly growing field. The National Science and Technology Council (2018) also states, increasing access to STEM education will not alone result in increased representation. It is necessary to go beyond traditional lines of research and pay greater attention to specific ethnic group influences such as the role of key cultural values to increase representation of Hispanic groups in STEM.

Hispanic ethnic identity is important to examine because it is a complex developmental process often involving a variety of dimensions including, but not limited to acculturation, biculturalism, gender differences, and generational differences (Rivera-Santiago, 1996). These dimensions all have in common that they are tied in one way or

another to cultural perspectives, especially for Hispanic groups (1996). Measures such as the Multigroup Ethnic Identity Measure (MEIM; Phinney, 1992), used in the current study, were created to capture some of these dimensions of ethnic identity development for various ethnic minority groups because other questionnaires could not quite capture the developmental nuances faced by Hispanic and other ethnic identity groups. Work with acculturation specifically has found that changes in socioeconomic status can influence decisions of identifying with 'whiteness' and identification with their own Hispanic culture (Estrada, 1993). Therefore, it is necessary to consider the strength of Hispanic identity in research around Hispanic groups because this identity is intimately connected to culture and ultimately, their lived experiences.

The influence of Hispanic identity is also closely related to familial experiences this unit has been found to directly influence ethnic identity socialization (Umaña-Taylor et al., 2009). Specifically, *familismo* has been identified throughout the research literature as a central valued in Hispanic cultural identity (Lugo Steidel, & Contreras, 2003). Defined as a primary devotion to the family where all matters of family come first, it connects Hispanic family members to each other and creates supportive environments to increase positive youth development outcomes (Fulgini & Yoshikawa, 2003; Martinez, 2013; Valenzuela & Dornbusch, 1994). Hispanic cultural values related to gender roles and educational attainment are closely tied to the familismo process, such that Hispanic college students decision making is often determined by engendered beliefs and value systems disseminated through their familial networks (Hernandez et al., 2016; Rodriguez et al., 2019).

When specifically considering the influence of familismo and Hispanic students' persistence in STEM, the research has found differing results about the benefits of familial ties. For example, Hispanic students can experience difficulties in completing studies due to employment responsibilities as they have to address familial financial obligations (Flores, 2011; Gasbarra & Johnson, 2008; Taningco, 2008). Other studies have noted that Hispanic STEM students often made schooling choices based upon familial needs rather than what would be most advantageous academically (e.g. leaving home for college, not working; Flores, 2011; Hernandez et al., 2016; Taningco, 2008). However, other studies have found that Hispanic STEM degree attainment is influenced by a positive correlation between parental support and encouragement of academic success and motivations (Flores, 2011; Hernandez et al., 2016).

Given the clear relationship between Hispanic identity and familismo the current study defines them as a collective representation of Hispanic cultural influences. This is supported by the prior research that has found family and ethnic identity informs Hispanic students' perceptions of and identification with STEM-related education and careers. Unfortunately, few studies have specifically examined the ways in which these cultural frameworks informs their STEM identity and persistence in STEM in terms of degree completion and continuing career goals. The limited research that exists has found that familial conversations about STEM throughout childhood contributed to Hispanic undergraduate's STEM identity (Dou & Cian, 2020). However, the degree to which this was tied to the specific influence of Hispanic ethnic identity and familismo was not examined. To date, there are no quantitative studies that specifically measure STEM

majors' persistence across the STEM pipeline of undergraduate degree completion and career choices as it relates to cultural influences exclusively in Hispanic populations.

Current Study

This study seeks to address these voids in the literature by examining how the Hispanic cultural values- ethnic identity and familisimo -influence Hispanic undergraduate's perception of themselves and career aspirations using an integrative theoretical model. The researchers situate this work within Relational Developmental Systems theory (RDST), which enforces a holistic, non-linear approach to understanding bidirectionality, coaction, and emergence in developmental change over time (Overton, 2015). The goal of this research is to move from traditional reductionist methods to a more holistic perspective that allows us to look at what variables (STEM identity, ethnicity, and parental support) from what levels of organization (institution type, STEM majors), at what points in an individual's life (emerging adulthood) will lead to what short- and long-term outcomes for both the individual (persistence, STEM success) and his/her context (adapted from Lerner et al., 2011).

Within this theoretical background, the researchers also utilize the framework of Relational Cultural Theory (RCT; Miller, 1976). This theory compliments RDST because it keeps in line with RDST's goal of moving away from reductionism and isolationism and focuses on the connections that result in the emergence of growth from relationships (Miller, 1987; Ruiz, 2005). This is important to examine in the context of STEM success for Hispanic students as it could be used to possibly explain how success is the emergence of growth from Hispanic families. RCT approaches this connectedness and growth from strengths-based perspectives meant to value these connections positively

(Jordan et al., 1991; Miller, 1986; Ruiz, 2005). It focuses on five main types of growth through the concept of mutuality: (1) enthusiasm from reciprocating connections, (2) action from reciprocated empowerment that results in change emerging from encounters, (3) learning resulting from of individuals getting to know more about others and themselves, (4) increased self-worth from reciprocal acknowledgement of one's lived experiences, and (5) pursuing more connection from having positive associations with another individual. It has been a framework traditionally applied to women's psychological experiences, it shows consistency with cross-cultural application and is especially relevant when applied to Hispanic, collectivist cultures that rely on connectedness (Ruiz, 2005). Little research exists specifically applying RCT to Hispanic cultural influences in the pursuit of STEM, but some research has used it with Hispanic evaluations to examine RCT in the context of STEM mentorship for Latinx students (Buehler, 2017). Therefore, based on it is past applications, flexibility, and similarity to RDST, it will be used to better explain culture's influence on STEM outcomes for Hispanic undergraduates.

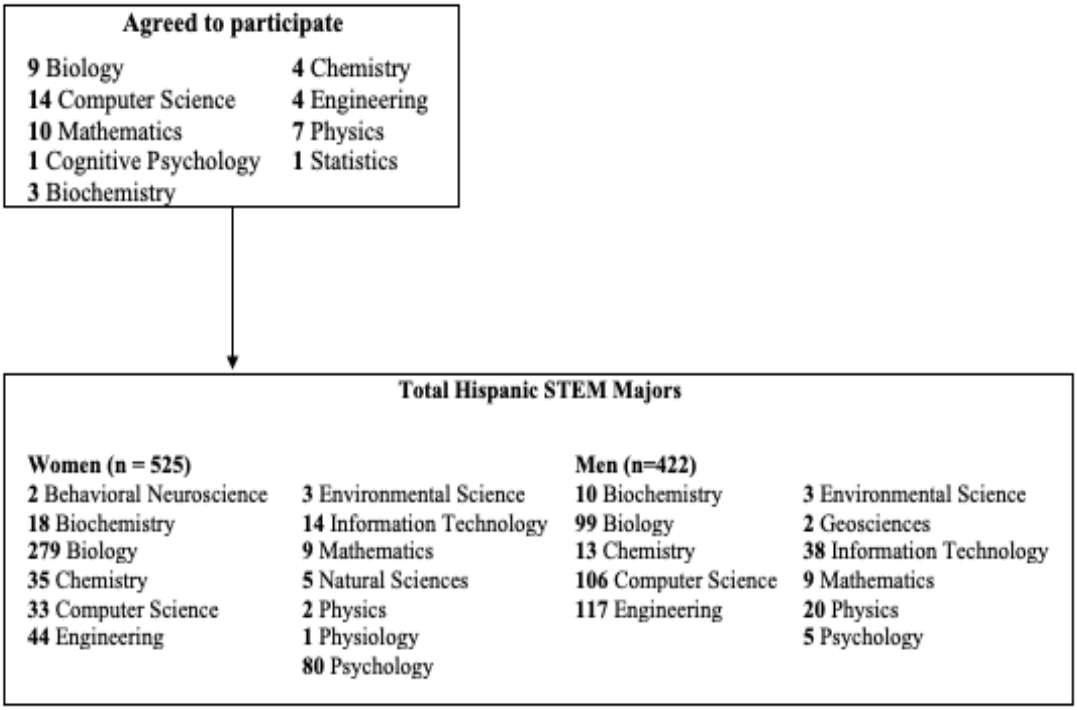
In the present study, multigroup structural equation modeling (SEM) methods were used to examine the influence of Hispanic identity and familismo on Hispanic undergraduate STEM major's STEM identity, and persistence in STEM, both toward degree completion and career goals. We anticipate that higher associations with being Hispanic and a commitment to family will positively predict perception as a 'STEM person', the student's intent to continue in STEM, and their STEM-related career aspirations.

Methods

The researchers recruited participants by emailing faculty teaching STEM courses during the summer of 2020. Ultimately, 38 courses across different STEM disciplines participated (Figure 1). These professors were provided with a unique Qualtrics link to share online with their students. The link would take participants to an online survey where they completed an online consent form. After consenting, students were directed to the full survey. Upon completion, participants were given information for on-campus counseling resources and asked to navigate to a separate Qualtrics link to provide their information to receive extra credit at the professor's discretion. The information provided in the extra credit form could not be linked to the participant responses and was done purposely in order to protect the identities of the participants.

Figure 1

Recruitment Visual



Participants

A total of 947 Hispanic undergraduate STEM majors (men= 422, women =525) between the ages of 18-29 (M_{age} = 22.17, *SD* = 2.42) participated. Participants were recruited from a large Hispanic-Serving Institution (HSI) located in the South Eastern region of the U.S. with an undergraduate population of over 50,000 students. Reported familial nations of origin included Cuban, (37.68%), American (18.18%), Venezuelan (6.37%), Colombian (6.19%), and others. A total of 830 (87.65%) of the participants lived at home with family members, while only 8 (.84%) resided on campus (see Table 1).

Table 1

Students' Living Arrangements

Living Arrangement	Total	%
With at least one family member	830	87.65%
With romantic partner	64	6.76%
With friends	13	1.37%
In a dormitory on campus	8	.84%
Alone	1	.11%
Did not answer	31	3.27%

Measures

The Multigroup Ethnic Identity Measure. The MEIM is a widely used instrument to assess the strength of ethnic identity in individuals by looking at factors such as affirmation, belonging, and commitment (Phinney, 1992; Roberts et al., 1999). It is a 15-item scale where responses are rated on a 4-point scale ranging from "strongly disagree" to "strongly agree." The internal consistency was considered adequate for the sample, $\alpha = .90$.

Familism Scale. Lugo Steidel and colleagues (2003) developed a scale to evaluate how closely Latino populations identify with traditional beliefs concerning *Familismo* within their families. It consists of 18-items scored on a 10-point scale ranging from "strongly disagree" to "strongly agree". The internal consistency was considered adequate for the sample, $\alpha = .79$.

Career aspirations. To assess the STEM career aspirations of students, an unpublished scale from Brandt (2014) was adapted and used. The career aspirations sub-scale originally consists of 13-items rated on a 5-point scale ranging from "strongly disagree" to "strongly agree.", however researchers were specifically interested in the questions related to feelings surrounding future STEM career options. Researchers ran reliability analyses on these five items of interest and the internal consistency was be found to considered moderate for the sample, $\alpha = .69$.

Science identity. Young and colleagues (2013) developed a science identity scale for use with undergraduate women to assess the influence of women science professors. The researchers were specifically interested in one item that was adapted to reflect STEM broadly: *Being a STEM student is an important reflection of who I currently am.* The item was rated on a 7-point scale ranging from "strongly disagree" to "strongly agree."

STEM retention measure. A measure to evaluate the intent of leaving STEM was developed by Perez and colleagues (2014). The researchers were specifically interested in one item that was adapted to reflect STEM broadly: *I am likely to remain in my STEM major or STEM related track through to graduation or completion of my program of study.* The item was rated on a 6-point scale ranging from "strongly disagree" to "strongly agree".

Demographics questionnaire. Participants were also asked demographic questions to collect age, gender, marital status, languages spoken, college major, race, and ethnicity, as well as their socioeconomic backgrounds.

Analytic Plan and Data Screening

Descriptive analyses were conducted using R Studio and preliminary analyses were done in SPSS. To evaluate the missingness of the data, Little's MCAR test was run and found that the data were not missing at random (Little's MCAR χ^2 (6329) = 6917.641, p <.001). The percentage of missing data ranged from .1% to .6% across items. To address missing values, researchers utilized SPSS to conduct imputations using Expectation-Maximization (EM). EM is a frequently used missing data method because it produces relatively unbiased estimates for item-level missing data (Enders, 2003).

Data were analyzed via multigroup SEM, which allows for testing of a model in two or more groups and provides the within and between group estimates (Jöreskog, 1971; Sorböm, 1974). The structural invariance of the model across the men and women groups were evaluated by testing an unconstrained model using freely estimated parameters. The fit of this unconstrained model was then compared to a constrained model where the paths across the two groups were set to be equal.

Results

The fit of the model degraded significantly when the paths were constrained, χ^2 (4) = 13.399, p = 0.009, insinuating that there was a difference in the strengths of the relationships between men and women. Theoretically meaningful modification index of correlating related error terms were suggested and applied. Therefore, the path coefficients and model fit for the unconstrained model are reported below. This non-

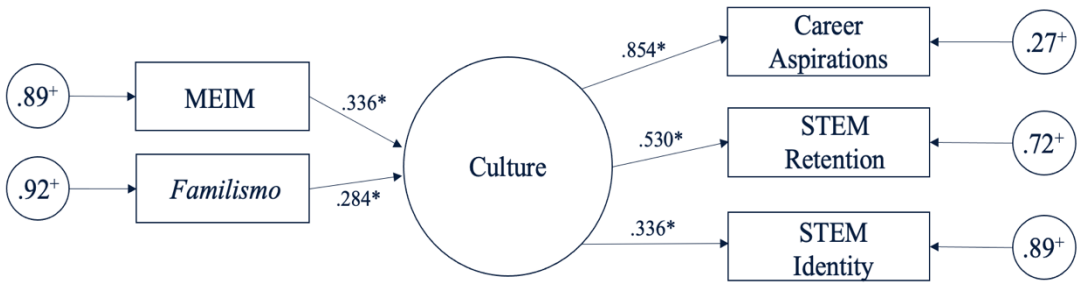
significant chi-square value indicates that the model operates statistically similarly for men and women. The fit indices of hypothesized models indicated relatively good model fit (RMSEA = 0.05, 90% CI [0.027– 0.075], p-close test of model fit = 0.45, CFI = 0.96, TLI = 0.88). With the fit of the model significantly degrading when the paths were constrained, the strength of the path coefficients differed by gender. As such, we detail the model parameters for the different groups (men and women) separately below.

For men, overall identification with culture was significantly related to each of the STEM related outcomes in the model (Figure 2). A higher identification with Hispanic culture was related to a greater reflection of being a STEM student for men, (*B* = 0.899, SE = 0.223, β= .336, $p < 0.001$). A higher identification with Hispanic culture was also positively related to STEM career aspirations for men, (*B* = 5.89, SE = 1.44, β= .854, $p < 0.01$). A higher identification with Hispanic culture was also positively related to staying in a STEM major for men, (*B* = 0.920, SE = 0.188, β= .530, $p < 0.01$).

.854, $p < 0.01$). A higher identification with Hispanic culture was also positively related to staying in a STEM major for men, (*B* = 0.920, SE = 0.188, β= .530, $p < 0.01$).

Figure 2

Model Results for Hispanic Men

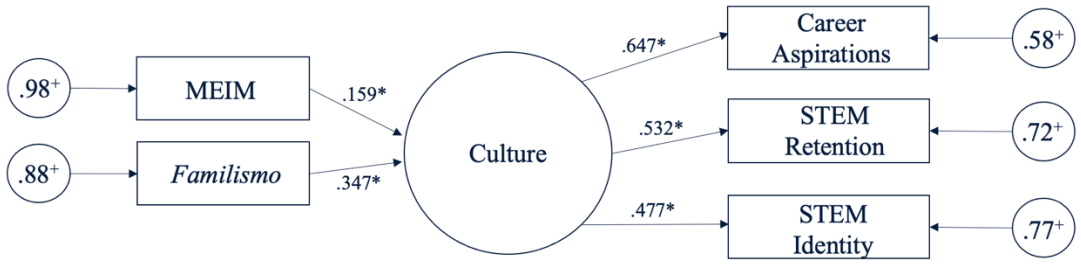


*p < .001; + squared multiple correlation

Women's overall identification with culture was significantly related to each of the STEM related outcomes in the model (Figure 3). A higher identification with Hispanic culture was related to a greater reflection of being a STEM student for women, (B = 1.03, SE = 0.215, β = .477, p < 0.01). A higher identification with Hispanic culture was also positively related to STEM career aspirations for women, (B = 3.59, SE = 0.767, β = .647, p < 0.01). A higher identification with Hispanic culture was also positively related to staying in a STEM major for women, (B = 0.822, SE = 0.167, β = .532, p < 0.001).

Figure 3

Model Results for Hispanic Women



*p < .001; + squared multiple correlation

The links between culture and identification with STEM, STEM career aspirations, and intention to stay in STEM were clearly significant for both Hispanic men and women, replicating prior research in these areas (Alfaro et al., 2006; Foltz et al., 2014; Lozano et al., 2018; Martinez et al., 2004; Peralta et al., 2013; Plunkett & Bámaca-Goméz, 2003). However, because the constrained model was significant, the strength of the relationships between culture and STEM outcomes differed by gender.

Discussion

The present study focused on examining the relationship between culture on STEM retention, STEM identity, and STEM career aspirations. The SEM analyses found that the latent variable of culture significantly predicted higher STEM identity, retention, and career aspirations for both men and women, but differed in strength of relationships, especially with regards to career aspirations. This is an important finding as it highlights the influence of Hispanic cultural attributes (family and ethnic identity) on educational success is more nuanced than what previous research has asserted (Foltz et al., 2014; Lozano et al., 2018; Peralta et al., 2013). This was not surprising given over 80% of the students in this study lived at home with their families; for these students the presence of their families increased the saliency of familismo values in their daily lives. Further, as they attended an HSI where over 70% of the student population self- identified as Hispanic, ethnic identity values would be central to both their socialization and academic experiences in their learning contexts (NCES, 2018).

Culture was significantly predictive of Hispanic men and women's intent to remain in a STEM major, STEM identity and STEM career aspirations. This supports the RCT support and connectiveness research such that Hispanic families are essential in creating STEM dispositions at home (Dou & Cian, 2020) and that Hispanic parental support is positively correlated with academic-related motivations (Alfaro et al., 2006; Martinez et al., 2004; Plunkett & Bámaca-Goméz, 2003). This also reinforces the importance of familismo's centrality in providing supports that impact Hispanic STEM

majors' self-perceptions in persisting in STEM (Ruiz, 2005). Thus, it is important that we frame Hispanic undergraduate's STEM experiences and movements through the STEM pipeline from a non-deficits based approach to the roles of culture and utilize RCT's framework to focus on the positive and growth contributing factors of Hispanic cultural values.

These results do require us to extend our considerations of within group differences related to the role of Hispanic cultural influences on STEM persistence. Specifically, there were gender differences in the strengths of the relationships observed. On most of the STEM related outcomes (e.g. STEM identity and STEM retention), the relationships for Hispanic women were slightly higher than Hispanic men's. However, for STEM-related career aspirations, the influence of culture was lower in strength than it was for Hispanic men. This finding is important as the education research is increasingly becoming mixed in its position about Hispanic culture's traditional gender role influences on women's education attainment outcomes (e.g. marianismo, "good daughter"; Hernandez et al., 2016; Rodriguez et al., 2019a; Rodriguez et al., 2019b). More recent studies have highlighted that families are very supportive of their daughters pursuing undergraduate and graduate degrees, particularly in the sciences (Flores, 2011; Hernandez et al., 2016; Peralta et al., 2013; Pietri et al, 2019). Issues that affect family member's support in these cases are lack of understanding of what STEM career options are available for daughters upon graduation (Flores, 2011; Hernandez et al., 2016; Pietri et al, 2019), familial economic support needs (Peralta et al., 2013), and curriculum and role model exposure (Peralta et al., 2013; Pietri et al, 2019). Recognizing this, future research should examine potential additional levels within the RDS systems that

influence Hispanic women's STEM career aspirations. Specifically, issues such as socioeconomic, institutional and regional context, immigration, and generational status are important to consider along with gender in future research seeking to expand our understandings of Hispanic women's STEM career attainment (Flores, 2011; Hernandez et al., 2016). This would be particularly true for the current study, as these women were attending a university where Hispanic women made up more than 57% of the total campus population, including as students and graduate students in STEM fields. This shift from framing Hispanic women- and men's- experiences in STEM as homogenous is important for discerning the complex relationship of family, ethnic identity, and STEM success. Thus, any potential cultural variations in the findings observed in the current study should be further investigated.

Limitations. It is important to note the potential limitations of the present study. The data were collected using self-report measures which are known for issues with validity and social desirability bias in responses (Paulhus & Vazire, 2007, Chapter 13). Researchers were also specifically interested in specific questions from measures not normed on Hispanic populations. It is possible that these questions operated differently in a Hispanic sample despite the adequate to strong internal consistencies (Sijtsma, 2009). Future work should look to conducting confirmatory factor analyses on these measures to confirm that they are operating similarly within a different population. Participation was also only open to individuals in STEM courses whose professors agreed to distribute the survey. Therefore, the percentage of participation from each STEM major was not equally balanced (Figure 1). Finally, this sample drew from students attending an HSI located in an urban center where over 70% of residents self-identify as Hispanic (U.S

Census, n.d). Arguably, these findings apply to a unique population of Hispanic students and should not be generalized to all Hispanic undergraduates pursuing STEM.

Conclusions. Despite the limitations, the current study contributes to the conversations surrounding how culture influences Hispanic students persisting and succeeding in STEM. It also highlights that Hispanic culture is complex, but can contribute positive influences to the movement of Hispanic students through the STEM pipeline. This study is particularly important given that few studies exist that exclusively focus on a large sample of Hispanic STEM majors; as such, these findings provide comprehensives insights into the fastest growing population on U.S. campuses today. This sample size also allows for identifying the ways in which cultural values can operate differently within groups, in this case in respect to gender. The present work focused on defining culture through Hispanic identity and family, situating these factors within the theoretical frameworks of RDS and RCT. These are arguably assets-based theories that highlight the importance of better understanding the nuances within Hispanic groups to provide empowering research that hopefully extends to culturally focused policy changes. It is clear that the rates of underrepresentation for Hispanic undergraduates in STEM are a serious issue that must be addressed via culturally sensitive and responsive methods that go beyond focusing on deficits based approaches.

V. CONCLUSION

As the fastest growing minority group in the nation and across U.S. campuses today, it is concerning that Hispanic college students trajectories in STEM fields do not align with their demographics in these settings. Drawing from an innovative, theoretical, and strengths-based perspective this study provides data via multiple forms of data. First, the systematic review highlights the need for evaluation of STEM focused programs that serve Hispanic groups. Unfortunately, these programs provide limited assessment information for underrepresented groups and it remains unclear if these programs are truly benefitting UREM populations (U.S. Government Accountability Office, 2018). It is necessary to evaluate the effectiveness of STEM programs to better serve UREM students, especially Hispanic groups who hold less representation shares in the STEM workforce (Pew Research, 2018). Proper evaluation can aid in identifying what aspects of programs work significantly and which do not. This allows for evidence-based restructuring to create truly effective programs so that commonly shared goals of increasing UREM, such as Hispanic groups, can truly be successful.

The second study is unique in its centering of a larger sample of Hispanic students' perspectives of the barriers and supports to success in STEM. No studies to date have gathered qualitative data from a sample of this size to provided participant driven answers about what needs to be addressed to increase both the recruitment and retention of Hispanic students in STEM degrees. The findings point to specific barriers and sources of support that require researchers to expand their understandings of how to assess these concerns in the future, while simultaneously offering program designers specific points for intervention in current programming. Further, these results highlight the important

role of context; interventions must move from a "one size fits all" approach to considering the saliency of acculturation, location, and immigration status when serving the needs of Hispanic STEM majors.

Relatedly, the third study expands our understanding of the intersecting role of gender in understandings about STEM identity, degree persistence, and career goals. Although there were similarities in the majority of the findings, the relationships were mostly stronger for women, challenging traditional assertions in the fields. Researchers are encouraged to move beyond the traditional deficit models of *marianismo* and *machismo* as problematic for Hispanic women in STEM and expand notions of Hispanic womanhood to embrace a more nuanced and complex experience across these fields. Clearly, it is also important that interventions focus on the differing needs of Hispanic men and women during their pursuit of STEM degrees.

Overall, these studies will force researchers to move from framing Hispanic student populations as homogeneous populations to truly understand the deeper understandings of context, culture, and identity's role in facilitating increased outcomes for Hispanic STEM majors. To make STEM more accessible, diverse, inclusive and socially just, more rigorous research is needed. The findings from this work have the potential to serve as a foundation for the effective restructuring of education and support programs. These programs need to become more inclusive, diverse, and accessible, while simultaneously taking into account the differences that exist within different groups. This is achievable if we provide simple, actionable, evidence-based ways that mentors, educators, and other people along the STEM pipeline can use to help minorities succeed,

especially Hispanic groups. Translating this research has the potential to make real policy differences and positive impacts amongst underrepresented groups.

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SELECT PUBLICATIONS & PRESENTATIONS

1. Agarwal, R., Bravo, E. I., Madhivanan, P., & Taylor-Amador, S. (2019). Methodological concerns with a recent systematic review. *Australian Critical Care.*

2. Bravo, E. I., Helpingstine, C., Stephens, D. P., & Madhivanan, P. (2019, October). *The Effectiveness of university STEM support programs in promoting STEM entrance and achievement among undergraduate Hispanics*. Poster presented at the National Latinx Psychological Association, Miami, FL.

3. Bravo, E. I., Helpingstine, C., Stephens, D. P., & Madhivanan, P. (2019, June). *Hispanic women persistiendo in STEM: A systematic review*. Poster presented at the Society for the Psychological Study of Social Issues (SPSSI), San Diego, CA.

4. Valentin, K., Bravo, E., & Stephens, D. P. (2019, March). Hispanic college women's perceptions of appropriate sexual initiation communication strategies with men. Poster presentation at the Conference for Undergraduate Research at FIU, Miami, FL.

5. Saunders, J. F., Bravo, E. I., Eaton, A. A., & Stephens, D. P. (2019, January). *The role of la familia during eating disorder recovery*. Poster presented at the National Multicultural Conference and Summit (APA Division 17), Denver, CO.