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RESEARCH ARTICLE

Across the Urban Divide: STEM Pipeline Engagement among Nonmetropolitan Students

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Abstract

Previous research highlights STEM educational inequities within various demographic groupings. However, little research explores the role of geography in STEM talent development. The present study assesses interest in and progression toward postsecondary STEM credentials among nonmetropolitan high school students (including rural areas and small towns) in the USA. Utilizing a national longitudinal dataset, the study finds nonmetropolitan high school students to be interested in STEM careers at rates equal to or greater than metropolitan students. However, our findings suggest that there are unique barriers on route to college for nonmetropolitan students. In general, geography alone does not account for differences in the educational pathways of nonmetropolitan students—in many cases, K-12 school characteristics play a more important explanatory role. The results of the present study may be useful in further understanding geographic inequity and identifying approaches to facilitate college degree attainment for the significant number of rural and small town students who are interested in a STEM career field.

Keywords STEM · Geography · Spatial inequality · Nonmetropolitan

The past several decades have seen a vigorous discussion in the USA about the importance of STEM talent development and the economic imperative to produce additional STEM workers. Nearly 10 years ago, the administration of U.S. President Barack Obama codified this issue with the call for 1 million additional college graduates in STEM disciplines by 2022 (Olson and Riordan 2012). By 2016, the

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demand for STEM talent had prompted federal funding of $3 billion annually for STEM education and the deployment of over 160 STEM educational programs (Government Accountability Office 2018). Analysts argue that a greater focus on STEM is vital for U.S. national interests, with the National Science Board contending that "A STEM-capable workforce provides the U.S. with an enduring competitive advantage" (2018, para. 4)—especially as the demand for employees with STEM expertise expanded by nearly 34% over the past decade. Corporations and private foundations have also invested hundreds of millions of dollars in funding to enhance the STEM pipeline (Gates Foundation 2018; Stych 2018). In the most recent iteration of STEM policy discourse, the administration of U.S. President Donald Trump has called for greater attention toward the "Industries of the Future" (IotF) such as artificial intelligence, quantum computing, biotechnology, and advanced manufacturing. The President's Council on the Advancement of Science & Technology (PCAST) projects hundreds of billions of dollars to be spent on research within these fields in the coming years and proposes the development of new national research centers dedicated to these areas (Schwarber 2020). Broadly speaking, the production of STEM talent continues to occupy a central role on the national stage—driving educational research, programming, and discourse.

Conversations around STEM talent production often highlight inequities within these fields, and numerous researchers and policy-makers advocate for STEM reforms to expand access for women, low-income students, and racial minorities. Recent investments in STEM education are aimed at diversifying pathways to STEM careers through curricular revisions, enhanced support networks (e.g., mentoring), and many other targeted interventions (Doerschuk et al. 2016; Ellis et al. 2016; Griffin et al. 2010; Jones and Cleaver 2020; Kendricks et al. 2013; Rincon and George-Jackson 2016). Some studies focus on the role of the learning environment (Gasman and Nguyen 2014; Griffith 2010; Hall et al. 2017). Workplace cultural and environmental factors (Sassler et al. 2017) have also been assessed for their importance in facilitating a successful transition to STEM careers for women and underrepresented minorities.

The present study extends the present discourse on equity within STEM educational pathways by focusing on an additional dimension of access: geographic locale. Our analyses draw primarily upon the High School Longitudinal Study of 2009 (HSLS:09), which captures STEM experiences and outcomes for students during their high school years and up to 3 years beyond high school (2009 through 2016). Specifically, we explore pathways toward STEM career fields for high school students in metropolitan and nonmetropolitan locales within the USA. Increasingly, geography has come to be viewed as an important differentiator in access to educational opportunities (Dache-Gerbino 2018; Hillman 2016; Peterson et al. 2015). The same is true for access to STEM educational initiatives, which include their own unique challenges and opportunities (Bybee 2013). As argued by the U.S. Department of Education (2020, para. 1): "We must… make sure that, no matter where children live, they have access to quality learning environments. A child's zip code should not determine their STEM fluency."

Purpose of this Study

As STEM occupies a prominent role in global educational and economic domains, it is worth questioning whether these pathways are fully accessible to students in every corner of the USA. The present study focuses attention on the concept of spatial inequality and its effects on those who enter and move through STEM educational pathways. We particularly focus on nonmetropolitan students—those who live and have received their high school education outside of metropolitan statistical areas (MSAs) in the USA—as a larger proxy for "the rural school problem" (Biddle and Azano 2016), which has drawn growing attention from researchers and policy-makers in recent years due to an increasing sense of educational and economic marginalization in America's hinterlands (Cann 2017). Given the fact that STEM jobs are increasingly viewed as pathways to economic mobility (NSB 2016)—and the persistent challenges of stimulating economic growth in nonmetropolitan contexts (Ulrich-Schad and Duncan 2018)—we felt that focusing on STEM pathways for nonmetropolitan students was important. And, given prior research highlighting the obstacles to postsecondary success for rural students (Koricich et al. 2018; McNamee 2019; Means et al. 2016; Tieken 2016), we specially chose to focus on key moments in the high school to college transition for STEM-interested youth as a potential area of risk for departure from STEM pathways. The most recently available national longitudinal dataset which focuses on this point in students' educational journeys is the HSLS:09 survey that we deploy in the present study.

Our adoption of the metro–nonmetro distinction aligns with the definition employed by the U.S. Office of Management and Budget (OMB), which considers all counties which are not part of a MSA to be either micropolitan (communities of less than 50,000 in population) or rural (US Department of Agriculture 2019). As the U.S. Department of Agriculture contends, "Studies designed to track and explain economic and social changes often… use the metro–nonmetro classification, because it reflects a regional, labor-market concept" (2019, para. 11) and is readily deployed based on the availability of country-level data. There is some question whether limited academic or extracurricular offerings in K-12 schools in nonmetropolitan rural and small town locales (those with 50,000 or less in population size) may constrain students from considering STEM majors and/or careers—an issue which will also be explored in this analysis. If correlations do exist between nonmetropolitan geographic contexts and STEM postsecondary outcomes, such factors may ultimately influence nonmetropolitan student career tracks and their earning potential, as well as local or regional economies.

We focus our STEM pathway analysis using a spatial inequality lens (Lobao et al. 2007), examining whether the uneven distribution of educational resources influences nonmetropolitan students' pursuit of future educational and career opportunities in STEM fields. Social cognitive career theory (SCCT) (Lent et al. 1994) further informs the present study as a means of understanding factors that may shape students' interest formation and decision-making about STEM career fields. The guiding focus of the present study is whether geography—and particularly nonmetropolitan status—may play a role in STEM talent development. Specifically, our research questions are:

1. Does geographic locale (i.e., nonmetropolitan status) affect student pathways within STEM, beginning with declared intentions in high school to attain a STEM career? and
2. Do students' personal or social cognitive characteristics, as well as high school environmental contexts (including metropolitan or nonmetropolitan geographic locale) influence their progression toward STEM postsecondary credentials—

including college enrollment, level of postsecondary institution attended, and selection of or persistence in a STEM major?

A better understanding of the influence of geographic locale on students' thinking about and access to STEM career pathways may help high school counselors and college officials determine how to equitably prepare students for the pursuit of related postsecondary opportunities. For example, if some nonmetropolitan students lack access to the academic resources, college-going support systems, and financial means needed for college, they are more likely to turn away from college enrollment before giving it due consideration. Loss of nonmetropolitan students in STEM career pathways translates into lost human capital, possible lower lifetime earnings, and conceivable losses in quality of life for these students.

Literature Review

The scholarly context for the present study requires consideration of three key bodies of literature: (1) studies on STEM talent development; (2) studies on nonmetropolitan educational pathways; (3) literature on the interplay between geography and access in higher education. Because no cohesive body of literature focuses explicitly on micropolitan or "small town" educational contexts, we equate nonmetropolitan with rural for the purposes of our literature review, as rural education research offers the best proxy for understanding nonmetropolitan schooling. This broader conceptualization appears regularly in scholarly literature on K-12 and postsecondary education (Domina 2006; Beggs et al. 1996; Griffin et al. 2011; Mills and Hazarika 2001; Walker and Raval 2017), although we should note that this correlation is problematic in that nonmetropolitan does not *always* mean rural (Isserman 2005) and vice versa. We will further discuss the justifications for this approach in our methods section. Below, we discuss each of the relevant research areas in turn as a means of situating the current study within broader scholarly discourse.

STEM Talent Development

STEM Defined STEM is broadly defined as the academic and career fields associated with science, technology, engineering, and math, although it should be noted that this definition can vary widely depending on the forum. For example, the National Science Foundation (NSF) uses a wide-ranging definition of STEM that includes not only engineering, technology, life sciences, and physical sciences but also social science disciplines and analytical fields such as economics. The National Science Board's *Science & Engineering Indicators* report (NSB 2016, pp. 3–5) highlights the significance of this variation, claiming that in 2013 "estimates of the size of the [science and engineering] workforce ranged from approximately 6 million to more than 21 million depending on the definition used." For the purposes of the present study, we rely primarily on a definition of STEM espoused by the Department of Education's SMART Grant program (US Department of Education 2018). The ED SMART program targets a narrower range of academic disciplines which includes the life sciences, physical sciences, natural sciences, agriculture, computer science and technology, engineering, and select social science fields such as psychology and linguistics (see Appendix for full list). This limited scope carries the added advantage of including the disciplines that are most prominently featured in public policy discourse about STEM talent demands (Xie and Killewald 2012).

Of course, in many empirical studies, emphasis on STEM degree attainment focuses largely on baccalaureate degree programs. It is important to note here that the U.S. STEM workforce includes a considerable number of "skilled technical workers"—as many as 16 million—for whom an associate's degree, trade school, or certificate program are the necessary entry points into a STEM career. Such career fields are high-paying, demographically diverse, and critical to nation's economy and infrastructure (NSB 2018). In the present study, we seek to account for student pathways into skilled technical roles by considering college entry at the certificate and/or associate's degree level in addition to 4-year college enrollment.

Pathways in STEM As referenced above, increasing scholarly and policy focus has been aimed at producing more STEM talent in the USA, largely as a means of maintaining global economic competitiveness. An important cornerstone of STEM policy discourse is the notion of the STEM "pipeline," often used to characterize the process of talent development as students move through secondary education (or even earlier grades) and various postsecondary settings to begin their career. However, the notion of a STEM pipeline has been criticized for its homogenizing and over-simplified conceptualization of STEM talent development (Cannady et al. 2014; Mendick et al. 2017; Metcalf 2010). In the present study, we rely instead upon the metaphor of STEM pathways, which Cannady et al. argue "…[convey] something more malleable and open to investigation, scrutiny, boundary exploration, and revision than the pipeline model" (2014, p. 456). In the case of the present study, furthering our understanding of the interwoven influences of geography, personal characteristics, and school characteristics in STEM talent development necessitate first an acknowledgment of the complex and diverse routes by which students arrive at a STEM career—routes which have many twists, turns, off-ramps, and on-ramps along the way.

Through their analyses of STEM pathways, scholars in education and other fields have invested a significant amount of time examining various contexts in which STEM success does (or does not) occur. Many such studies have suggested that initial interest in STEM and the foundational skills necessary for long-term success are established in K-12 settings, with high school being a particularly important time for the development of math and science self-efficacy (Almarode et al. 2014; Maltese and Tai 2011; Moakler and Kim 2014; Tyson et al. 2007; Wang 2013; Wilson et al. 2013). Maltese and Tai (2011), for instance, posited that growing interest in math and science coursework during high school years is a key driver in establishing a desire for continued learning in STEM disciplines during college. Relatedly, Almarode et al. (2014) found that students' positive perceptions of their intellectual capacity for science, math, and/or engineering as juniors or seniors in high school were associated with a higher likelihood of earning a STEM degree in college. Research by Wang (2013) yielded similar findings, with 12th-grade math achievement and exposure to math and science courses being positive predictors of postsecondary STEM interest. Increasingly, K-12 settings are also being understood as important venues for students to begin applying STEM concepts to real-world problems, developing scientific literacy, and utilizing problem-based inquiry to solve challenges (Cahill 2016; Martín-Páez et al. 2018; Noble et al. 2020). In some instances, K-12 STEM learning outcomes are framed in the context of broad "21st Century Skills" (Partnership for 21st Century Learning 2016) such as knowledge construction, collaboration, or skilled communication (Stehle and Peters-Burton 2019).

Demographic Trends Previous studies have also highlighted the potential effects of characteristics such as gender, race/ethnicity, socioeconomic status (SES), and parental education on a student's likelihood of earning a degree in STEM (Dabney et al. 2013; Tai et al. 2006), with some gaps emerging quite early in students' K-12 educational journeys (Betancur et al. 2018). Generally, demographic studies have highlighted the fact that Asian students are among the most highly engaged in STEM disciplines (Beede et al. 2011; Crisp et al. 2009; Steenbergen-Hu and Olszewski-Kubilius 2017), with White students often benefiting as well from a strong sense of self-efficacy within STEM academic settings (Garland and Rapaport 2017). However, studies controlling for variables such as gender, immigrant status, and parental education frequently find little to no difference in STEM interest and participation between racial or ethnic groups (Lichtenberger and George-Jackson 2013; Maltese and Tai 2011; Ozis et al. 2018). Several researchers have concluded that Black students actually participated in STEM programs at higher rates than White students when controlling for academic preparation (O'Brien et al. 2015; Riegle-Crumb and King 2010).

When specifically examining the role of gender, a consistent body of research shows reduced participation rates among women (Blickenstaff 2005; Tyson et al. 2007). While women often demonstrate similar STEM capabilities as men (Ozis et al. 2018), they may be more likely than their male counterparts to depart from the STEM pipeline at key milestones such as calculus coursework (Ellis et al. 2016). In part, these differences in persistence may be attributed to differences in self-perceptions between men and women regarding their potential capacity for success in STEM (Weber 2012) or differences in women's sense of belonging within their respective STEM fields (Rainey et al. 2018). Notably, gender gaps in STEM participation often remain even within educational contexts that otherwise seem supportive of STEM talent development (Ketenci et al. 2020). While these characteristics are treated as control variables in the present study, this body of literature highlights the salience of demographic factors to educational and policy discourse on STEM talent development.

STEM Educational Interventions There is also a growing body of research that explores the effectiveness of targeted programs and resources to enhance STEM success in postsecondary settings. For example, Rincon and George-Jackson (2016) found that a wide range of STEM recruitment and retention initiatives existed within the U.S. postsecondary landscape, including programs offering enhanced academic advising, financial support, mentoring and social support structures, targeted professional development, and/or hands-on learning and research opportunities. Many STEM higher education initiatives seek to enhance connections between students and faculty members or provide deeper exposure to STEM career fields (Doerschuk et al. 2016; Ononye and Bong 2018). Meanwhile, other analyses focus on barriers to degree completion or successful career transition in STEM fields (Jelks and Crain 2020; Smith and White 2019; Xu 2013). Increasingly, scholars are taking a longitudinal view in understanding how STEM talent development occurs through the P-20 pipeline and beyond. The emergent themes within this body of literature suggest that coordinated support in postsecondary settings can and does influence STEM success, but “input” factors established prior to arrival in higher education often continue to play an outsized role in STEM degree attainment (Le and Robbins 2016).

At the K-12 level, several notable educational interventions have emerged to drive further student engagement in STEM. One example is Project Lead The Way (PLTW), a nonprofit organization that provides “transformative learning experiences for PreK-12 students and teachers across the U.S.” (PLTW 2020). PLTW strives to enhance STEM education in PreK-12 settings through the provision of teacher training and hands-on curriculum modules in areas such as computer science, engineering, or biotechnology. Lesson plans are designed to be project based and compatible with Common Core Standards (Cahill 2016; Pike and Robbins 2019). To date, the PLTW program has expanded to include more than 12,000 schools in the USA and facilitated training for more than 77,000 teachers (PLTW 2020). Previous scholars have found evidence that PLTW serves as an effective driver of student interest in STEM (Hess et al. 2016) and facilitates students’ transition to two- and four-year colleges (Rethwisch et al. 2013). In a recent quasi-experimental analysis within the state of Indiana, Pike and Robbins (2019) found evidence of a causal relationship between PLTW program participation in high school and selection of a STEM major in college. Effect sizes for PLTW participation were related to dosage amounts (i.e., one high school course versus two or three courses), and the authors also found that larger high schools were more likely to deploy PLTW curricula. Notably, lower-tier socioeconomic school districts were also more likely to utilize PLTW modules, although racially diverse schools were less likely to participate. Such findings reflect the fact that even large-scale STEM educational interventions may be deployed unevenly across the geographic landscape. However, PLTW remains a promising model for supporting not only PreK-12 students in STEM but also STEM educators.

Rural Postsecondary Access

High school contexts—including geographic location and availability of funding—may demonstrate significant influence on curricular (and extracurricular) offerings and students’ plans to attend postsecondary education. Environmental factors are also important for more fully understanding student-level characteristics such as race and family socioeconomic status (Engberg and Wolniak 2009). While the study of STEM talent development in nonmetropolitan contexts has been limited, there is a growing body of literature that examines the role of rurality in STEM educational pathways. In general, studies of rural K-12 schooling examine issues such as attitudes toward formal schooling (Corbett 2007; Dees 2006), career aspiration formation (Ali and Saunders 2009), and the influence of school and community in shaping students’ future plans for school and career (Tieken 2016; Kryst et al. 2018). For instance, Dees (2006) found that rural attitudes about higher education may be complicated by factors such as valuing “common sense” over intellectual ability and adherence to traditional gender norms. Chenoweth and Galliher (2004) also commented on the role of rural educational contexts, arguing that forces of localism, historicism, and familialism foster deep attachments to community, place, and family for rural students.

Researchers have found evidence that rural schools often exhibit lower levels of per-pupil funding (Roscigno and Crowley 2001) or college preparatory support (Ardoin 2018; Means et al. 2016), and recent policy analyses argue that rural schools may often provide fewer opportunities in Advanced Placement (AP) STEM coursework (Mann et al. 2017; Gagnon and Mattingly 2016). In part, this lack of AP course offerings is linked to shortages of qualified STEM teachers in rural settings or fewer resources to allocate toward STEM education (Harris and Hodges 2018; Peterson et al. 2015; Yaffe 2018). In a review of literature on rural STEM education, Harris and Hodges (2018) found compelling evidence of STEM inequities between rural and nonrural K-12 school districts that included differential access to resources; cultural and economic differences influencing student orientations toward STEM; and disparities in STEM outreach and support efforts in rural settings. Yettick et al. (2014) found that K-12 teachers in rural Colorado consistently cited funding as a significant barrier, while nonrural teachers did not make this claim with the same frequency. The same study demonstrated that rural schools often declined to pursue additional STEM educational funding due to the administrative burdens associated with such awards—and even when grants were obtained, funding formulas tended to disadvantage small-town schools due to their overreliance on factors such as enrollment size. Meanwhile, a number of researchers have argued that rural schools and communities actively track high-achievers toward continuing education opportunities by allocating these limited resources toward a select handful of students (Carr and Kefalas 2009; Sherman and Sage 2011).

Scholars interested in postsecondary access have explored these questions further in recent years, examining whether and how rurality influences college student success. Several studies have highlighted findings that rural students are less likely to enroll in postsecondary education (Byun et al. 2015; Koricich et al. 2018) or enroll in institutions with lower selectivity (Bowen et al. 2009; Hillman 2016) despite the fact that such students often graduate high school at rates equal to or higher than their non-rural peers (Schafft 2016). Examining national longitudinal data, Koricich et al. (2018) found that rural students were only 85% as likely as non-rural students to enroll in college, and only 70% as likely to enroll in research universities. Other scholars found that rural students tend to enroll disproportionately in community colleges (Byun et al. 2017) or otherwise undermatch themselves when selecting a college or university (Smith et al. 2013). Because nearly 60% of baccalaureate students at public colleges enroll within 50 miles from their permanent home (Eagan et al. 2014), rural students are more likely to feel the effects of educational deserts (Hillman and Weichman 2016). Having fewer colleges close to home may increase transportation costs for rural students and necessitate creative partnerships between postsecondary institutions and rural schools and communities seeking to increase college access.

Once rural students arrive in postsecondary institutions, unique barriers remain within their education paths, including cultural dynamics such as the prevalence of gendered career norms, pragmatic worldviews, and potentially a greater sense of community attachment and/or religiosity (Byun et al. 2012; Corbett 2007; Corbett 2009; Dees 2006) or even challenges related to linguistic hegemony (Dunstan and Jaeger 2016). Notably, rurality is often associated with other marginalized student identities such as low-income or first-generation status (Ardoin 2018; Hand and Payne 2008). Overall, scholars of rural education argue that these sociocultural and socioeconomic dynamics may result in misalignment of the social, cultural, and academic capital necessary to succeed in postsecondary settings (McNamee 2019).

The Geography of Opportunity

Given what the literature suggests about educational equity gaps for rural students, how and why does geographic inequity take place? Hillman (2016) offers one of the most compelling explorations of geographic inequity, arguing that over-emphasis on the *process of opportunity* in higher education (i.e., recruitment and admissions) ignores larger structural limitations created by the spatial distribution of educational opportunities. Hillman found, for example, that rural populations often have better access to 2-year institutions than 4-year institutions in terms of geographic proximity. Dache-Gerbino (2018) extended this argument in her study of postsecondary opportunities in Rochester, New York, arguing that both *power geometry* (the false notion that the world is getting "flatter" due to technology) and *spatial mismatch* play an important role in postsecondary access (see Massey 1994). Generally, college proximity researchers argue that living nearer to a 4-year institution may positively impact both educational aspiration formation and application/enrollment outcomes (Klasik et al. 2018; Ovink et al. 2018), what Turley (2009) referred to as the "predisposition mechanism" or "convenience mechanism," respectively. Although the current study does not specifically capture geographic distance from postsecondary institutions, consideration of spatiality is a central aim of this project. As a result, it is helpful to keep in mind the potential influence of college proximity when interpreting the results of the present study.

These findings align with the conclusions of other researchers about the structural barriers evident when deploying both state and intermediary educational initiatives (Johnson et al. 2014). Other relevant structural barriers include difficulties in recruiting qualified STEM teachers to rural schools, human capital flight, inadequate facilities, and general remoteness (Boynton and Hossain 2010; Harmon and Smith 2012; Kelly 2016), as well as a limited ability to provide ongoing professional development opportunities for rural teachers (Yettick et al. 2014). Parental expectations for students' career paths may also be incongruent with STEM degree attainment in rural settings, where the pursuit of such opportunities often entails permanent departure from the community (Harris and Hodges 2018). Given these pressures, and the general importance of firsthand experiences with diverse career opportunities in the development of educational and career aspirations (Elam et al. 2012; Zimmerman and Weible 2017), fostering access to STEM educational pathways in nonmetropolitan settings requires a number of unique considerations.

Conceptual Framework

The present study draws upon two theoretical frameworks. The first framework is spatial inequality (Lobao et al. 2007), which assesses the impacts of differential resource allocation across the geographic landscape. Put differently, spatial inequality focuses on the role of uneven development within the broader context of social stratification. By acknowledging the fact that economic resources and opportunities are distributed unevenly across geographic space (i.e., urban, suburban, and rural locales), we can further consider how such resource allocations in turn affects the development of social and cultural capital (Bourdieu 1986) or academic capital (Stich 2012) which are important assets for the pursuit of economic goals. The spatial inequality framework particularly emphasizes the role of social institutions in crystallizing social inequities. Educational systems, for instance, not only channel economic resources but also affect the development of various forms of capital through mechanisms such as the provision of AP coursework, extracurricular activities, or curated pathways toward certain career fields or degree programs.

The present study also relies upon social cognitive career theory (SCCT) as a conceptual framework for specifying the various influences that may propel students toward or away from STEM career paths throughout high school and the first several years of college (Lent et al. 1994, 2000). SCCT emphasizes three general developmental influences to career choice: personal attributes, social cognitive traits, and environmental characteristics. Aside from geographic locale (conceptualized here as a key component of the environmental context), salient characteristics might include race, gender, and socioeconomic status (personal attributes), high school grade point average and prior STEM experience in AP coursework (social cognitive traits), and other relevant school–community environmental characteristics such as school size, percentage of students receiving subsidized lunches or high school college and career support mechanisms (e.g., internships, college/career fairs, financial aid information sessions).

Also central to SCCT are the concepts of self-efficacy and outcome expectations. Self-efficacy might be described as a self-belief one holds about their ability to perform well in a particular domain (in this case, STEM coursework and career fields). This self-belief can be fostered in four primary ways: (1) through vicarious experiences; (2) through personal performance accomplishments; (3) through social persuasion; (4) via physiological and affective states (Lent and Brown 1996). Closely related to this concept are outcome expectations, which can be a motivating factor when considering the potential value of various career fields. Perceived benefits to pursuing a particular career track, especially when coupled with positive self-efficacy in related skill and knowledge areas, can reasonably be expected to draw one toward that particular field. As this conceptual model suggests, self-efficacy and outcome expectations are also closely intertwined with goal-setting behavior. Furthermore, SCCT posits that self-efficacy and outcome expectations are influenced heavily (and in complex ways) by personal, social cognitive, and environmental variables (Lent et al. 1994).

In the present study, we hypothesize that geographic locale (e.g., nonmetropolitan context) directly influences many of these dimensions of self-efficacy development within STEM domains. Vicarious experience, for example, may be more difficult to obtain in settings with limited economic diversity (i.e., fewer roles models in engineering, technology, or scientific fields). Likewise, in nonmetropolitan schools where fewer STEM AP courses are offered, students have limited opportunities to achieve personal performance accomplishments within the formal curriculum. Finally, while many previous studies have emphasized the roles of personal or social cognitive traits in STEM education and career development, the present study focuses more heavily on the environmental characteristics of SCCT (see also Ketenci et al. 2020). While geography is centered within the theoretical model for the present study, the roles of related characteristics such as school size, educational resources, and college/career support are also considered here.

Method

The primary data for the present study are restricted-level variables from the *High School Longitudinal Survey of 2009* (HSLS:09). HSLS:09 was a nationally representative longitudinal study of over 25,000 ninth graders beginning in 2009, with subsequent follow-ups in 2012, 2013, and 2016. The HSLS project included surveys of students, parents, math and science teachers, high school counselors, and administrators. Student participants were followed throughout their secondary education and up to 3 years after high school graduation (NCES 2018). Of particular interest for the present study are the HSLS:09 measures for math and science course-taking behaviors during high school and other personal, social cognitive, and environmental factors related to future STEM career trajectories.

Given the fact that the HSLS survey is based upon a two-stage random sampling process (e.g., random sampling of school districts and then random sampling of students within participating school districts), survey weights are necessary to account for non-responses and to adjust survey metrics to be nationally representative. The present study deployed restricted-level Taylor series linearization weighting techniques designed specifically by the NCES for complex survey analysis utilizing all four waves of data collection. For more information on NCES weighting protocols, see Duprey et al. (2018). All numbers and results reported in the present study are rounded to the nearest ten per NCES reporting guidelines for restricted-level student datasets.

Due to the central focus of locale in the present study, participants who moved high schools between the first and second wave of the survey were dropped from the analysis. As a result, our initial sample consisted of 19,150 students. Given that NCES conducts imputation processes on longitudinal datasets when possible, any remaining missing observations for the study's input variables were dropped from the analysis. Irrelevant records were also removed for some portions of the analysis, such as the omission of non-college goers from models assessing STEM major choice and persistence in college. The sample size became progressively smaller as each stage of the STEM pathway was examined, with the last model examining STEM major persistence 3 years after high school containing 7,310 participants.

Dependent Variables

The outcome measures of interest for the present study include seven distinct variables, each representing a pivotal moment in high school-to-college STEM educational pathways. These include (1) whether the participant anticipated being in a STEM career field by age 30 (obtained by HSLS during the student's freshman year of high school), (2) whether the participant anticipated being in a STEM career field by age 30 (asked again during the student's junior year of high school), (3) whether the participant enrolled in college (2-year or above) within 3 years after high school graduation, (4–5) whether differences emerged between initial enrollment in the 2- and 4-year sectors (two models), (6) whether participants majored in a STEM field upon college entry (only for those students who matriculated in 4-year colleges), and (7) whether participants were still majoring in a STEM field in the final 2016 follow-up (for those who come into college as a STEM major). As mentioned previously, the STEM definition for the present study was based upon the ED SMART grant program—some outcome measures were constructed utilizing this definition and others were readily available within the HSLS:09 dataset. Table 1 contains descriptive statistics for the variables used in our analyses.

Independent Variables

Independent variables for the present study were chosen with consideration given to both spatial inequality and social cognitive career theory (SCCT). Conceptually, the personal and social cognitive characteristics described in SCCT were collapsed into one grouping that included student demographics (sex, race, and socioeconomic status) as well as parental educational expectations, first-generation student status, and academic performance measures such as high school GPA and math/science AP course participation. Further reflection on the SCCT framework resulted in a selection of variables that might depict differences within the high school environment, such as the percentage of low-income students (as measured by free and reduced lunch eligibility), number of AP courses offered, or high school enrollment size. Composite indices were developed for HSLS measures about AP course offerings, college-going support, and career education activities at the high school level. These factors were generally developed using lists of dichotomous survey responses from the HSLS:09 high school administrator and/or counselor survey responses. For example, the career education index includes 18 indicators for whether the school offers supports such as career fairs, internships with employer partners, or computerized career resources. The college support index similarly is composed of 11 indicators for resources such as college info sessions, college tours, or support with the college application process. It should be noted that these variables measure only curricular and extra-curricular *offerings* at participating high schools and not actual student engagement with these resources. Table 1 provides more information about independent variables and their conceptual groupings according to the SCCT framework. For our purposes, the explicit focus on K-12 environmental characteristics is important, as spatial inequality theory conceptually links social institutions to resource availability and—by conjunction—subsequent educational or economic outcomes.

Locale Finally, a key emphasis of the present study is the exploration of how geographic locale potentially influences STEM talent development. After considering various options for understanding the effects of urbanicity/rurality, we chose to organize our analysis around the U.S. Office of Management and Budget (OMB) metropolitan locale classification. This measure is somewhat broader than the default U.S. Census Bureau locale coding which is embedded within HSLS (e.g., rural, town, suburban, urban). The OMB classifies areas as metropolitan if they are part of a metropolitan statistical area which includes at least one urbanized area of 50,000 or more inhabitants. Based upon the latest U.S. Census Bureau data (in this case, 2010), metropolitan classifications occur at the county level and often include adjacent areas that are closely linked through commuting activity. Micropolitan counties include an

Table 1 Descriptive statistics for dependent and independent variables (weighted)

Variable name	Observations (rounded to nearest 10)	Mean	Linearized SE	95% CI	
Dependent variables					
Expectation of STEM career at age 30 (base year)	19,150	0.3046	0.0068	0.291	0.318
Expectation of STEM career at age 30 (follow-up 1)	19,150	0.3346	0.0069	0.321	0.348
College enrollment (2 or 4 yr)	19,150	0.7649	0.0065	0.752	0.778
College level	19,070	1.08	0.0103	1.06	1.100
Four-year college enrollment	19,070	0.329	0.006	0.317	0.341
Declaration of STEM major	16,520	0.2788	0.0075	0.264	0.293
Persistence in STEM major	11,000	0.4378	0.0133	0.412	0.464
LOCALE variable					
Nonmetropolitan	17,710	0.1220	0.0034	0.115	0.129
PERSONAL variables					
Male	19,150	0.5035	0.0075	0.489	0.518
White	19,150	0.5411	0.0069	0.528	0.555
Black	19,150	0.1239	0.0054	0.113	0.134
Asian	19,150	0.0395	0.0023	0.035	0.044
Hispanic	19,150	0.2082	0.007	0.194	0.222
Native	19,150	0.0116	0.0018	0.008	0.015
Race/ethnicity—other	19,150	0.0757	0.0043	0.067	0.084
SES composite	19,150	−0.0210	0.0104	−0.041	−0.001
SOCIAL COGNITIVE variables					
Parent education expectations	17,550	6.0837	0.0532	5.98	6.188
First-generation status	19,150	0.4489	0.0075	0.4342	0.4636
High school GPA	18,690	2.8073	0.0136	2.781	2.834
AP math credits	18,710	0.2007	0.0064	0.188	0.213
AP science credits	18,710	0.2126	0.0066	0.2	0.226
ENVIRONMENTAL variables					
School free lunch pct	18,160	4.3774	0.0310	4.317	4.438
Scale of HS math teacher's self-efficacy	15,310	0.0202	0.0211	−0.021	0.062
Low resource school	17,060	0.8718	0.0111	0.850	0.894
HS career education index	19,150	7.4396	0.0587	7.326	7.555
HS college support index	19,150	7.1368	0.0356	7.067	7.207
HS AP offerings index	19,150	3.7963	0.031	3.736	3.857
School size (in 100s)	19,060	13.6631	0.0862	13.494	13.832
Private school	19,150	0.0727	0.0011	0.071	0.075

Source: High School Longitudinal Survey of 2009 (NCES). Weighted descriptive data obtained by applying Taylor linearization weighting techniques using *W4W1W2W3STU* (restricted-level data). Further details on variable definitions or weighting techniques are available from authors upon request urbanized setting of 10,000 to 50,000 inhabitants, while some counties that fit neither the metropolitan or micropolitan categorizations might be considered completely rural. In this manner, the metropolitan classification system includes considerations of geographic proximity and economic connectivity that the four-part U.S. Census Bureau locale coding is unable to capture. In fact, a substantial number of small town (about 85% of the small town subgroup) and rural (about 23% of the rural subgroup) HSLS participants actually fell within a metropolitan area due to these guidelines.

Given that the OMB metropolitan classification was not originally embedded within the HSLS survey design, additional K-12 school records from NCES' Common Core of Data (CCD) and the Private School Universe (PSS) surveys were used to derive a nonmetropolitan classification for public and private schools, respectively. In each instance, CCD and PSS survey data were utilized to link county names and unique school identifiers with OMB delineation files for 2013. From this point, all metropolitan locales were assigned a value of "0" and all nonmetropolitan locales (including any micropolitan or rural county outside of a MSA) were assigned a value of "1." Some missing values were imputed manually by researching population data on individual counties, while any remaining unmatched records were assigned a missing value and dropped from the analysis. Overall, 17,710 participant records were successfully assigned an OMB designation.

Analytical Plan Following a descriptive analysis, a series of seven hierarchical logistic regression models were constructed utilizing the theoretical framework and the dependent/independent variables listed above. Most logistic regression results are reported here in terms of marginal effects (with the exception of Table 5, given that the "College Level" analysis utilizes ordered logit), wherein a single unit change in the independent variable may be interpreted as corresponding to a percentage change in the likelihood of the outcome variable of interest (e.g., majoring in a STEM field) also occurring. For each logit model, the following formula was employed:

$$\ln\left(\frac{P}{1-P}\right) = \alpha + (LOCALE)\beta + (PERSONAL + SOCIAL\ COGNITIVE)\vartheta + (ENVIRONMENTAL)\gamma + \varepsilon \quad (1)$$

Using this statistical approach, we conceptualize of our input variables as belonging to three distinct vectors within SCCT theory: PERSONAL and SOCIAL COGNITIVE (combined here to simplify our hierarchical analytical structure), and ENVIRONMENTAL. LOCALE, which is of primary interest here, is assessed through a dichotomous "Nonmetro" variable which is assigned a value of "1" for locales which are considered Nonmetropolitan according to the U.S. Office of Management and Budget (OMB) metropolitan/micropolitan delineation system. It is important to note that some variables within the ENVIRONMENTAL vector (e.g., high school size, low-resource school indicators) may be directly or indirectly associated with geographic context. The use of numerous ENVIRONMENTAL variables allows us to better understand the true significance of nonmetropolitan status while controlling for other factors related to one's school district or community context.

Limitations

We acknowledge that the HSLS data used for the present study is based on self-reported data (i.e., parental educational aspirations for their child) and as such is subject to responses that are influenced by social pressures or personal perceptions. A second limitation of the present study is our reliance upon new derived variables to address the research questions of interest. For example, a variable on first generation status was constructed through a review of participant responses about parental education levels. In most cases, this was not a significant hurdle. In other instances, the survey design of HSLS was more limiting—such as when seeking to explore curricular or extracurricular STEM career/industry engagement in high school, which is assessed through an extensive list of dichotomous measures (e.g., "Yes, the high school offers computerized career resources"). More detailed metrics about these resources, as well as student engagement with these offerings, would have been helpful. We have also limited the findings somewhat by examining a narrower definition of STEM disciplines (using ED Smart versus NSF categorization). While there are advantages to this approach, such as being able to scope policy discourse more effectively, it does omit a number of career and academic fields from this analysis. Finally, we acknowledge that we have assessed spatiality in a somewhat limited way in the present study through our emphasis on nonmetropolitan locale classification. While there are many more nuanced ways to analyze spatial statistical data, it is our hope that this generalized approach will provide a starting point for further discourse on this topic.

Additional limitations include the possibility of omitted variable bias, which we acknowledge as a potential concern. For example, the NCES weights we have applied in our models help to correct for nonresponses and over/under sampling within the research design—however, the weights are applied based upon the variables we have included and therefore our findings may not be fully generalizable. We also have not fully addressed the concept of self-efficacy in the models presented in the present study. Although we draw heavily upon other aspects of social cognitive career theory (SCCT) to frame our analysis, it should be noted that self-efficacy is a key concept in this model that could be addressed more directly in future analyses. We should also underline the analysis presented herein is not based upon a randomly controlled trial, and therefore any claims we make should not be interpreted as causal. Particularly given our emphasis on logistic regression analyses, we focus instead on how various characteristics are related to the *probability* of a given outcome—keeping in mind that factors outside of our models may also be influencing student pathways in STEM.

Results

We began our analysis with a review of descriptive statistics to assess differences in STEM pathway outcomes based upon locale alone. Utilizing weighted means for the study's outcome variables, we begin to see a general narrative unfolding around nonmetropolitan student experiences (see Table 2). Several additional key variables are also shown in Table 2, based upon their relevance to the findings reported below. First, it is apparent that students in nonmetropolitan locales within the HSLS sample had a comparatively strong interest in STEM career fields during high school—holding equal or greater interest levels in STEM than their metropolitan peers, with nonmetropolitan STEM career interest appearing to trend upwards between freshman and junior years of high school. Table 2 also highlights dramatic differences in first generation status and math and science AP course completion for nonmetropolitan students, in addition to differential college enrollment outcomes. A two-sample adjusted Wald test shows that these differences are statistically significant at the $p < 0.01$ level. There were also stark differences in K-12 school characteristics, as nonmetropolitan schools differed significantly from metropolitan schools in regard to enrollment size, percentage of students receiving free or reduced lunch, and school control (i.e., public vs. private). In general, these weighted descriptive statistics framed an interesting picture for our subsequent analysis and seemed to confirm what previous literature suggests about potential barriers for students from outlying geographic contexts. We next interpret logistic regression results for our dependent variables of interest: STEM career interest at age 30 (captured at two points during high school), college enrollment (any college, level of college enrollment, as well as 4-year college enrollment specifically), and entry into or persistence toward a STEM major. Our analysis relies upon a threshold of $p < 0.01$ for statistical significance in order to minimize the risk of Type 1 errors within our interpretation.

Table 3 shows marginal effects for the first set of logistic regression models, which assess whether or not the HSLS participant expected to hold a career in a STEM field at age 30. This question was asked once during the respondent's ninth-grade year (Base Year (BY)), and again in their junior year of high school (Follow Up One (F1)). As seen here, nonmetropolitan locale exhibited a relationship with STEM career expectations that was not statistically significant early in high school, with factors such as sex, parental educational expectations, and grade point average carrying more explanatory power. However, statistically significant differences did emerge in participants' junior year when nonmetropolitan respondents reported interest in STEM career paths at a rate greater than their metropolitan counterparts. In Model 5, which includes locale and personal/social cognitive determinants, this difference was over 5% greater, while the gap increased to 7.7% higher when accounting for K-12 school environment characteristics in Model 6. Factors such as sex, parental educational expectations, and high school grade point average continued to be important predictors of STEM career interest in Model 6, while the index for high school college-going support was also marginally significant at $p < 0.05$.

In Table 4, we see marginal effects for postsecondary enrollment, which includes four hierarchical models. Initial outputs in Model 1 underscore the findings from our descriptive analysis, showing that nonmetropolitan respondents were more than 9% less likely to enroll in college the year following high school completion. However, when accounting for personal/social cognitive factors (Model 2) and school environment characteristics (Model 3), locale becomes nonsignificant. Instead, factors such as socioeconomic status, grade point average, and attending a private high school signify a higher likelihood of college enrollment, while first generation status or attending a lower income school (as represented by percentage of free or reduced lunch recipients) signifies a lower likelihood of attending college. It is likely that this dynamic is due in part to high levels of correlation between nonmetropolitan locales and many of these variables. Notably, Hispanic students within the HSLS survey appeared more likely to enroll in college—a finding which deserves more exploration in future studies. In

Table 2 Comparing metropolitan and nonmetropolitan locales using weighted means

	Metropolitan	Nonmetropolitan
Dependent variables		
Base year STEM career interest	0.307	0.3
Follow-up 1 STEM career interest	0.328	0.353
College enrollment (2 or 4 yr)	0.78	0.697**
Four-year college enrollment	0.347	0.249**
Declaration of STEM major	0.283	0.243
Persistence in STEM major	0.439	0.383
Personal/social cognitive variables		
SES composite index	0.008	− 0.169**
First-generation status	0.437	0.511*
Parental education expectations	6.26	5.261**
AP math credits	0.234	0.108**
AP science credits	0.251	0.087**
K-12 school environment variables		
High school size	15.725	7.278**
School free lunch pct	4.232	4.755**
Low resource school	0.868	0.840
Private school	0.073	0.046**

Source: High School Longitudinal Survey of 2009 (NCES). Weighted descriptive data obtained by applying Taylor linearization weighting techniques using *W4W1W2W3STU* (restricted-level data)

*Significant difference in weighted means at $p < 0.01$ using adjusted Wald test

**Significant difference in weighted means at $p < 0.001$ using adjusted Wald test

Model 4, an additional input variable was added to capture high school STEM career interest ("1" if F1 STEM career interest was reported, "0" otherwise). This measure was also correlated to an increased likelihood of college enrollment (around 5% greater) and marginally statistically significant at $p < 0.05$.

Table 5 extends the analysis further by exploring patterns in 2- and 4-year postsecondary enrollment. "College Level" models show ordered logistic regression results based upon whether participants reported ending their education with a high school diploma ("0"), enrolling in a certificate program or associate's degree program ("1"), or enrolling in a 4-year degree-granting institution ("2"). Nonmetropolitan locales initially appear strongly linked to lower tier educational trajectories ($p < 0.001$), but much of this difference is explained by the addition of personal/social cognitive, environmental, or STEM career interest variables. In College Level Models 2–4, nonmetropolitan locale is marginally significant at the $p < 0.05$ level. Personal and social cognitive characteristics, in particular, appear to play an important role in college pathways, although it does appear that private high school enrollment also has a strong positive relationship with college-level outcomes. Similar results occur for 4-year college enrollment, where nonmetropolitan students appeared to enroll at lower rates than metropolitan students when holding constant other factors (although this difference is

Table 3 Marginal effects for STEM career interest in high school

	BY STEM career interest	BY STEM career interest	BY STEM career interest	F1 STEM career interest	F1 STEM career interest	F1 STEM career interest
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Nonmetro	− 0.016	0.015	0.015	0.017	0.055**	0.077**
	(0.016)	(0.019)	(0.026)	(0.016)	(0.020)	(0.024)
Male		− 0.097***	− 0.137***		− 0.107***	− 0.114***
		(0.015)	(0.019)		(0.015)	(0.019)
Black		− 0.017	− 0.067		0.066*	0.005
		(0.028)	(0.039)		(0.028)	(0.037)
Asian		0.103***	0.083*		− 0.001	0.004
		(0.030)	(0.037)		(0.034)	(0.043)
Hispanic		− 0.012	− 0.045		0.021	0.029
		(0.023)	(0.033)		(0.023)	(0.033)
Native		− 0.071	− 0.162		0.143*	0.170*
		(0.076)	(0.100)		(0.071)	(0.081)
Other		0.068*	0.061		0.013	− 0.027
		(0.031)	(0.040)		(0.028)	(0.037)
SES		0.004	0.025		− 0.005	− 0.007
		(0.012)	(0.016)		(0.012)	(0.017)
Parental education expectations		0.019***	0.015***		0.006*	0.013***
		(0.003)	(0.004)		(0.003)	(0.004)
First-generation student		0.022	0.028		− 0.019	− 0.009
		(0.019)	(0.027)		(0.020)	(0.026)
High school GPA		0.041***	0.026*		0.065***	0.069***
		(0.009)	(0.012)		(0.010)	(0.014)
School free lunch pct			0.011*			0.004
			(0.005)			(0.005)
Math teach efficacy			0.007			− 0.004
			(0.011)			(0.010)
Low resource school			− 0.001			− 0.003
			(0.013)			(0.013)
HS career education index			0.002			0.002
			(0.003)			(0.003)
HS college support index			0.007			0.009*
			(0.004)			(0.004)
HS AP offerings index			0.007			0.002
			(0.004)			(0.004)
School size			− 0.000			0.000
			(0.001)			(0.001)
Private high school			0.007			0.010
			(0.031)			(0.030)
AP math credits					− 0.001	− 0.017

Table 3 (continued)

	BY STEM career interest	BY STEM career interest	BY STEM career interest	F1 STEM career interest	F1 STEM career interest	F1 STEM career interest
					(0.015)	(0.020)
AP science credits					0.064^{***}	0.076^{***}
					(0.012)	(0.016)
Rounded *N*	17,030	10,870	6,170	17,030	10,870	6,170

Source: High School Longitudinal Survey of 2009 (NCES)

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

only significant in Models 5 and 6). Here, however, the effects of attending a low resource school ($p < 0.01$) appear to play a more important role than geography, in addition to private school enrollment ($p < 0.001$) and marginal significance for both high school college-going support and AP offerings ($p < 0.05$) (see Model 7). One might imagine how—for 4-year college enrollment in particular—factors such as these are important in creating a college-going culture within both metropolitan and nonmetropolitan school settings.

Finally, we explored the issue of entry into and persistence through a STEM college major via two additional hierarchical logistic regression models (not shown), exploring whether students intended to select a STEM major upon entry to college and whether students who *did* intend to major in STEM had persisted within a STEM major as of the final survey wave (likely their junior year of college). In all cases, nonmetropolitan locale was not found to be a significant factor at conventional levels of significance. Factors such as sex (i.e., being male), AP credit attainment, parental educational expectations, high school size, and high school STEM career interest seemed to carry the most positive significance for students transitioning initially into a STEM major. All of these factors were significant at $p < 0.01$ or lower, except for parental expectations and high school size which were marginally significant at $p < 0.05$. For persistence in STEM, several personal/social cognitive traits (being male, being Asian, high school grade point average, and AP credit attainment in science) were significantly linked to retention. High school STEM career interest also continued to relate strongly to STEM major persistence ($p < 0.01$). Meanwhile, no high school environmental characteristics were statistically significant in models examining STEM major persistence, suggesting (perhaps not surprisingly) that the effects of K-12 school environment diminish as one progresses further into their postsecondary education.

Discussion

As the results above suggest, geographic locale may have a significant influence on students' access to and success in STEM academic and career fields. Despite previous research which highlights the limitations of rural student career aspirations (Ali and

Table 4 Marginal effects for college attendance

	Model 1	Model 2	Model 3	Model 4
Nonmetro	− 0.093***	− 0.021	− 0.029	− 0.034
	(0.016)	(0.018)	(0.022)	(0.022)
Male		− 0.022	− 0.035	− 0.028
		(0.014)	(0.019)	(0.019)
Black		0.054*	0.072*	0.072*
		(0.022)	(0.033)	(0.033)
Asian		0.032	0.031	0.029
		(0.047)	(0.078)	(0.079)
Hispanic		0.067***	0.095***	0.091***
		(0.019)	(0.027)	(0.027)
Native		0.033	0.289*	0.268*
		(0.088)	(0.119)	(0.111)
Other		0.028	0.022	0.028
		(0.023)	(0.029)	(0.030)
SES		0.070***	0.049**	0.050**
		(0.013)	(0.016)	(0.016)
Parental education expectations		0.007**	0.008**	0.008*
		(0.002)	(0.003)	(0.003)
First-generation student		− 0.049**	− 0.066**	− 0.065**
		(0.016)	(0.021)	(0.021)
High school GPA		0.150***	0.144***	0.142***
		(0.009)	(0.012)	(0.012)
AP math credits		0.026	0.075	0.072
		(0.026)	(0.042)	(0.042)
AP science credits		0.023	0.026	0.020
		(0.017)	(0.026)	(0.026)
School free lunch pct			− 0.013**	− 0.012**
			(0.005)	(0.005)
Math teach efficacy			− 0.021*	− 0.020*
			(0.009)	(0.009)
Low resource school			− 0.013	− 0.012
			(0.012)	(0.011)
HS career education index			0.003	0.003
			(0.003)	(0.003)
HS college support index			− 0.004	− 0.004
			(0.004)	(0.004)
HS AP offerings index			− 0.001	− 0.001
			(0.003)	(0.003)
School size			0.002	0.002
			(0.001)	(0.001)
Private high school			0.178***	0.176***
			(0.038)	(0.038)

Table 4 (continued)

	Model 1	Model 2	Model 3	Model 4
HS STEM interest				0.049^{*}
				(0.020)
Rounded *N*	17,030	10,870	6,170	6,170

Source: High School Longitudinal Survey of 2009 (NCES)

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Saunders 2009; Burnell 2003; Meece et al. 2013), the data here show that nonmetropolitan high school students could very well be interested in STEM careers at rates equal to or higher than their urban and suburban peers. This discrepancy could be attributed in part to the fact that many studies of nonmetropolitan educational pathways (e.g., career and educational tracking in rural schools) are qualitative in nature or employ a relatively limited scope—for instance, focusing explicitly on low-income rural students or studying the formation of career aspirations within one state or a single community. As shown in the present study, nationally representative datasets offer the advantage of providing a comparison not only between student demographic characteristics but high school characteristics as well. Such research could be further extended in the future by including more variables related to the surrounding community or region.

Findings about STEM career interest among nonmetropolitan HSLS respondents also deserve further research. Why might students in outlying geographic locales embrace STEM career fields so strongly? One answer may lie in the pragmatism that is sometimes associated with rural education stakeholders. As previous scholars have suggested (Burnell 2003; Corbett 2009; Cox et al. 2014; Wright 2012), rural students and their families often display a tendency to gravitate toward practical academic pathways that lead to stable and rewarding careers. Highly visible and in-demand professions such as medicine, engineering, or computer science are examples of exactly such pathways, and many skilled workforce roles available within the 2-year college sector (such as medical technicians) are also STEM related. As a result, nonmetropolitan students may have a greater tendency to embrace STEM pathways that offer routes to a secure economic future. Future researchers should explore this idea in more detail. As suggested by Peterson et al. (2015), rural STEM interest may also be a useful economic lever for sustaining and reinvigorating nonmetropolitan settings that are still reeling from declining job opportunities in agriculture, manufacturing, or natural resource extraction over the past several decades.

However, there is some cause for concern that nonmetropolitan students may be less likely to make the transition from high school to postsecondary education. Our initial logit model in Table 4 (Model 1) showed that nonmetropolitan students were more than 9% less likely to enroll in any college in the year following high school. This finding is consistent with previous research showing that rural students are dramatically less likely to enroll in college (Koricich et al. 2018). In our analyses, personal/social cognitive and school environment characteristics accounted for much of this gap. The

Table 5 Logit results college level

	College level	College level	College level	College level	4-year college	4-year college	4-year college	4-year college
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Nonmetro	− 0.475***	− 0.201*	− 0.257*	− 0.264*	− 0.496***	− 0.293**	− 0.234	− 0.230
	(0.068)	(0.089)	(0.120)	(0.120)	(0.081)	(0.110)	(0.147)	(0.146)
Male		0.051	− 0.011	− 0.002		0.143	0.140	0.136
		(0.070)	(0.092)	(0.092)		(0.084)	(0.110)	(0.110)
Black		0.367**	0.408*	0.409*		0.220	0.145	0.145
		(0.133)	(0.187)	(0.188)		(0.178)	(0.242)	(0.241)
Asian		0.260	0.187	0.186		0.112	0.155	0.155
		(0.164)	(0.246)	(0.247)		(0.191)	(0.270)	(0.269)
Hispanic		0.099	0.076	0.074		− 0.414**	− 0.343	− 0.343
		(0.098)	(0.142)	(0.143)		(0.136)	(0.189)	(0.189)
Native		− 0.227	1.060	1.049		− 0.524	0.670	0.674
		(0.497)	(0.654)	(0.654)		(0.561)	(0.785)	(0.784)
Other		0.030	0.123	0.127		− 0.131	− 0.037	− 0.039
		(0.116)	(0.156)	(0.157)		(0.142)	(0.190)	(0.190)
SES		0.581***	0.423***	0.423***		0.621***	0.505***	0.506***
		(0.059)	(0.080)	(0.080)		(0.067)	(0.091)	(0.091)
Parental education expectations		0.088***	0.107***	0.106***		0.104***	0.120***	0.121***
		(0.013)	(0.017)	(0.017)		(0.015)	(0.018)	(0.018)
First-generation student		− 0.391***	− 0.416***	− 0.416***		− 0.459***	− 0.324*	− 0.323*
		(0.088)	(0.111)	(0.112)		(0.112)	(0.135)	(0.135)
High school GPA		1.182***	1.216***	1.212***		1.220***	1.269***	1.272***
		(0.054)	(0.078)	(0.079)		(0.061)	(0.083)	(0.084)

Table 5 (continued)

	College level Model 1	College level Model 2	College level Model 3	College level Model 4	4-year college Model 5	4-year college Model 6	4-year college Model 7	4-year college Model 8
AP math credits		0.288***	0.267*	0.268*		0.307***	0.185	0.185
		(0.085)	(0.111)	(0.112)		(0.092)	(0.120)	(0.120)
AP science credits		0.169*	0.170	0.164		0.118	0.158	0.162
		(0.074)	(0.101)	(0.102)		(0.081)	(0.108)	(0.109)
School free lunch pct			− 0.061*	− 0.061*			− 0.049	− 0.049
			(0.025)	(0.025)			(0.029)	(0.029)
Math teach efficacy			− 0.029	− 0.028			− 0.038	− 0.038
			(0.048)	(0.048)			(0.053)	(0.053)
Low resource school			− 0.087	− 0.087			− 0.180**	− 0.180**
			(0.058)	(0.058)			(0.062)	(0.062)
HS career education index			0.014	0.014			0.017	0.017
			(0.014)	(0.014)			(0.017)	(0.017)
HS college support index			0.018	0.018			0.049*	0.049*
			(0.020)	(0.020)			(0.023)	(0.023)
HS AP offerings index			0.013	0.013			0.050*	0.051*
			(0.019)	(0.019)			(0.023)	(0.022)
School size			0.008	0.008			0.001	0.001
			(0.007)	(0.007)			(0.009)	(0.009)
Private high school			0.748***	0.746***			0.682***	0.684***
			(0.153)	(0.153)			(0.172)	(0.172)
HS STEM interest				0.068				− 0.046
				(0.093)				(0.110)
/								

Table 5 (continued)

	College level Model 1	College level Model 2	College level Model 3	College level Model 4	4-year college Model 5	4-year college Model 6	4-year college Model 7	4-year college Model 8
cut1	− 1.183***	2.083***	2.370***	2.370***	0.621***	4.913***	5.605***	5.607***
	(0.034)	(0.172)	(0.301)	(0.302)	(0.029)	(0.215)	(0.377)	(0.377)
cut2	0.623***	4.798***	5.073***	5.074***				
	(0.028)	(0.187)	(0.319)	(0.318)				
Rounded *N*	17,300	15,630	10,740	10,740	17,300	15,630	10,740	10,740

Source: High School Longitudinal Survey of 2009 (NCES)

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

variables that were significant in these models are a laundry list of the educational risk factors that are commonly associated with nonmetropolitan contexts, including first-generation status, low socioeconomic status, and low-income enrollment within one's high school (see Table 2). Further research should explore this concept from a policy standpoint in order to assess whether educational interventions—and STEM education programs in particular—are effective in reaching outlying nonmetropolitan communities. Differences in college enrollment that initially appear connected to geographic locale may in fact be due to other factors that can be addressed through strategic policy levers.

The same narrative holds true in Table 5, where we see probability models for college enrollment level (high school versus 2-year versus 4-year college enrollment) as well as specific trends for 4-year college enrollment. While nonmetropolitan locale is significantly related to lower enrollment outcomes at the surface level, other personal/social cognitive and environmental traits again explain much of this variance. In both cases, socioeconomic status and parental educational expectations are linked strongly to enrollment outcomes, as is attending a private school. For 4-year college enrollment specifically, attending a low-resource high school appears to be a potential barrier. Each of these findings might be thought of as an important risk factor for college access policies targeting nonmetropolitan students. Scholarship programs or STEM pre-college programs could focus specifically on low-income nonmetropolitan students to facilitate enrollment, or perhaps focus more explicitly on engaging nonmetropolitan parents in the college-going process. Due to the fact that a significant geographic divide *does* exist—as shown before the addition of our explanatory variables—policy-makers should develop place-sensitive support systems that focus intentionally on sources of inequity *within* the nonmetropolitan landscape. Such steps are important and necessary given the national emphasis on STEM talent development and the high level of interest in STEM careers among nonmetropolitan students—in other words, many potential STEM workers may essentially be filtered out of STEM pathways due to their geographic circumstances.

For those nonmetropolitan students who do enroll in 4-year universities, it seems that geography may be increasingly less salient to their progression through STEM educational pathways. When examining initial declaration of a STEM major, we found that nonmetropolitan students were about 3.6% less likely to choose a STEM academic path (not a statistically significant difference at $p = 0.07$). More robust models showed that sex (i.e., being male), parental expectations, and math/science AP credit completion were more important than geography to this initial decision, as was STEM career interest in high school. High school size was also marginally significant ($p < 0.05$). From a policy lens, these findings suggest that efforts to increase AP course access in nonmetropolitan locales are vital for facilitating STEM success in these settings. High school size, for instance, is likely to be highly correlated with additional AP course offerings. Meanwhile, models for persistence in STEM majors showed no differences according to geography and only a handful of measures that were significantly related to continuity in 4-year STEM degree programs. These factors included being male, being Asian, high school grade point average, and science AP credit completion. Aside from AP course offerings, these factors are perhaps less salient to nonmetropolitan locales and access to STEM pathways at the K-12 level.

The recurring theme of this analysis is that nonmetropolitan locale, in and of itself, matters far less to STEM pathway success than other personal, social cognitive, and environmental characteristics. An example of this concept is seen in the findings for female students, who report a strong interest in STEM careers early on (Table 3) but reverse course in subsequent phases of their education. Family and community social structures affect and change young women's life and employment goals (Keith and McWilliams 1995; Risman 2004), and it is also well documented that STEM disciplines such as engineering, computer science, and math remain dominated by men despite growing gender equity in other STEM disciplines (Beede et al. 2011). Recent female interest in areas related to public health and health care (e.g., Sadler et al. 2014) may offer traction for female growth in STEM. It is important to underline that many such "personal" attributes such as self-perceptions of gender and race/ethnicity are significantly influenced by one's surroundings, including society at large (i.e., prevailing norms around who holds a STEM career) as well as the barriers, expectations, and supports within one's household and local community. Clearly, there are important effects for gender even when controlling for geographic context and other important factors. Consideration of SCCT concepts such as outcome expectations, goal-setting, and self-efficacy may offer further compelling policy solutions to address this issue—and might be designed to address the effects of locale as well. A nonmetropolitan- and female-centered STEM initiative might take into account factors such as parental educational expectations (a key influence in many of our models) or local contextual factors such as the potential lack of female STEM role models in nonmetropolitan communities. Rural education literature also suggests that students in nonmetropolitan settings may be subject to the effects of traditional gender norms (Ali and Saunders 2009; Dees 2006), suggesting that addressing both structural and cultural factors is important to fostering STEM pathway success specifically among nonmetropolitan women.

While differences in STEM educational pathways may be understood broadly in terms of geography, our findings suggest that researchers and policy-makers should take care to explore beyond superficial notions of locale to achieve a more nuanced understanding of educational contexts. As shown in many of the models within the present study—and as suggested by spatial inequality theory—social institutions (such as colleges and K-12 schools) have an important role to play in the equitable provision of opportunities. In addition, while scholars and policy-makers have cast a growing emphasis on supporting postsecondary access for rural students in recent years (Gettinger 2019; Gillespie 2018; Krupnick 2018), we offer the nonmetropolitan lens as an alternative approach to understanding the experiences of an oft-overlooked demographic—those in small town settings. Within our analysis, roughly 62% of our nonmetropolitan demographic hailed from areas the U.S. Census Bureau classified as small towns. Given the fact that many educational researchers rely upon geographic distinctions such as rural/non-rural, rural/urban, or rural/suburban/urban, this is an important point to acknowledge and a potential advantage of the nonmetropolitan/metropolitan classification. From a policy standpoint, one might imagine that there is also potential political leverage in the development of STEM workforce initiatives that explicitly focus on small town America.

As Massey (1994) argued, the exploration of various spatial dimensions is helpful in uncovering the issues of *power geometry* and *spatial mismatch*—the ideas that the world is not necessary becoming “flatter” for everyone and the geographic distribution of opportunities has real implications for individual and community outcomes. Further research may be helpful to explore whether the geography of opportunity (as articulated by Hillman 2016) is a possible cause for any differences in nonmetropolitan STEM pathways—that is to say, whether geographic access to STEM-focused institutions or degree programs somehow causes students to gravitate toward or away from these career fields or to opt into lower educational tiers after high school. At the very least, the present study offers a starting point for drawing further connections between geography and STEM success, suggesting several important considerations for future researchers who are interested in nonmetropolitan settings.

Conclusion

With its emphasis on progressive, systematic, and rational thought, it has been suggested that STEM is an inherently cosmopolitan endeavor (Ron 2016). The present study examined nonmetropolitan educational pathways that may be relevant to STEM talent development policies in the USA. Specifically, we highlight the presence of substantial interest in STEM career fields for nonmetropolitan high schoolers, which is followed by a complex narrative about the factors that shape college enrollment and STEM degree attainment. Our findings show that—although nonmetropolitan students are interested in STEM career fields at equal or greater rates than their metropolitan peers—nonmetropolitan pathways through the postsecondary landscape are influenced predominately by personal/social cognitive traits and K-12 school characteristics, and not geography alone. Some factors, such as attending a low-resource school, a school with a percentage of low-income students, a school with fewer AP offerings, or even a private school, may in fact be closely related to nonmetropolitan context. Other traits, such as socioeconomic status, first-generation status, or parental educational expectations, represent important household-level policy levers which might be integrated effectively into educational programs or interventions which are focused on particular places or regions. Nonmetropolitan settings may be well positioned to benefit, for example, from targeted economic and workforce development strategies which create more local educational and employment opportunities for STEM workers. Such policy designs should take into consideration the factors outlined in the present study, reaching beyond any particular geographic focus to address barriers at the household or school levels. Through the deployment of a broad metropolitan/nonmetropolitan analytical framework, we also suggest that there is inherent value in problematizing the traditional rural/urban dichotomy and bringing more stakeholders into STEM education policy discourse.

Research Ethics

The present study presents a secondary analysis of existing survey data from the National Center for Education Statistics (NCES) and therefore does not constitute human subjects research. Our analysis does utilize protected student-level data (through the permission of NCES) and all recommended NCES guidelines for use of such data were followed closely. The authors of the present study did not receive any funding to support this research.

Appendix

National ED SMART Grant Eligible Majors

Prior to the implementation of the National Science and Mathematics Access to Retain Talent (SMART) Grant program, the Secretary of Education designated the eligible fields of study. The listing below reflects eligible SMART Grant disciplines as of 2008-09, which were used as the defining parameters of STEM disciplines within this study. This appendix was reprinted from Appendix B of the U.S. Department of Education's (2011) Academic Competitiveness and National SMART Grant Programs: 2006–07 Through 2008–09 documentation, which was last retrieved by the authors on February 19, 2021 at the following URL: https://www2.ed.gov/rschstat/eval/highered/smart-grant/acg-smart-grant-report-year-third-final.pdf.

Computer Science:

The branch of knowledge or study of computers, including such fields of knowledge or study as computer hardware, computer software, computer engineering, information systems, and robotics.

Associated NCES CIP CODES: 11.xxxx

Engineering:

The science by which the properties of matter and the sources of energy in nature are made useful to humanity in structures, machines, and products, as in the construction of engines, bridges, buildings, mines, and chemical plants, including such fields of knowledge or study as aeronautical engineering, chemical engineering, civil engineering, electrical engineering, industrial engineering, materials engineering, manufacturing engineering, and mechanical engineering.

Associated NCES CIP CODES: 14.xxxx

Foreign Language:

Instructional programs that focus on foreign languages and literatures, the humanistic and scientific study of linguistics, and the provision of professional interpretation and translation services.

Associated NCES CIP CODES: 16.xxxx

Life Sciences:

The branch of knowledge or study of living things, including such fields of knowledge or study as biology, biochemistry, biophysics, microbiology, genetics, physiology, botany, zoology, ecology, and behavioral biology, except that the term does not encompass the health professions. This category also includes agriculture, agricultural operations, and related sciences.

Associated NCES CIP CODES: 26.xxxx; 01.xxxx

Natural Resources and Conservation:

Instructional programs that focus on the various natural resources and conservation fields and prepare individuals for related occupations.

Associated NCES CIP CODES: 03.xxxx

Psychology:

Instructional programs that focus on the scientific study of the behavior of individuals, independently or collectively, and the physical and environmental bases of mental, emotional, and neurological activity.

Associated NCES CIP CODES: 42.xxxx

Mathematics:

The branch of knowledge or study of numbers and the systematic treatment of magnitude, relationships between figures and forms, and relations between quantities expressed symbolically, including such fields of knowledge or study as statistics, applied mathematics, and operations research.

Associated NCES CIP CODES: 27.xxxx

Physical Sciences:

The branch of knowledge or study of the material universe, including such fields of knowledge or study as astronomy, atmospheric sciences, chemistry, earth sciences, ocean sciences, physics, and planetary sciences.

Associated NCES CIP CODES: 40.xxxx

Technology:

The application of mechanical or scientific knowledge, for example, applied science.

Related NCES CIP CODES: 41.xxxx; 29.xxxx 15.xxxx

Several Multidisciplinary Studies are also considered eligible for National SMART Grants.

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