HOW FAR CAN THEY GO?: ENGLISH LANGUAGE LEARNERS'
MATH COURSE TAKING IN HIGH SCHOOL
AND SCHOOL PRACTICES

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by
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The undersigned, appointed by the dean of the Graduate School, have examined
the dissertation entitled

HOW FAR CAN THEY GO?: ENGLISH LANGUAGE LEARNERS'
MATH COURSE TAKING IN HIGH SCHOOL
AND SCHOOL PRACTICES

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a candidate for the degree of doctor of philosophy,
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ABSTRACT

Over the last three decades in the U.S., schools have endeavored to provide more equitable access to rigorous courses, especially for racially or socioeconomically marginalized students, and increased those students' participation in higher level courses. Despite such improvement, the gaps in high level courses enrollment among racially or socioeconomically different student groups still remain with those marginalized students underrepresented in the high level courses. The present study focused on another marginalized group of students, English language learners (ELLs) and sought to identify school practices that may improve ELLs' access to advanced math courses in high school. Using the High School Longitudinal Study of 2009, the present study examined three key school practices in association with ELLs' taking advanced math: i) student choice-based math placement policies, ii) math encouraging programs for underrepresented students, and iii) math professional learning communities (PLC). The present study found that only math PLCs had a statistically significant association with the probability of taking advanced math courses, net of prior achievement and other student- and school-level factors. The math PLCs examined here represented a collaboration among math teachers to learn effective teaching methods and discuss their teaching/learning belief for students including ELLs or under-performing students. It found no differential effects of school practices and ELLs' taking advanced math courses, the main focus of this study. However, the findings indicate that ELLs can also benefit from high quality math PLCs as much as other students. The key finding of the present study suggests the possible area that school leadership and educators should develop to improve students' access to advanced math courses net of their prior achievement.

Particularly for ELLs, the finding suggests that training content area teachers may help ELLs more readily access academically challenging courses net of their academic performance. Most importantly, considering taking advanced math in high school is a critical issue for ELLs in regard to their participation in the STEM (science, technology, engineering, and mathematics) workforce in the future, there should be more research that explicitly investigates school policies and practices that may facilitate ELLs' access to higher level courses in high school.

keywords: English language learners, High School Longitudinal Study of 2009, math professional learning communities, student choice, advanced math

Chapter 1: Introduction

Taking advanced mathematics courses in high school is critical for preparing for science, technology, engineering, and mathematics (STEM) careers as it is predictive of high interest in STEM career (Warne, Sonnert, & Sadler, 2019) and college completion with a STEM degree (Ackerman, Kanfer, Calderwood, 2013; Tyson, Lee, Borman, Hanson, 2007; Wang, 2013). However, research has documented systemic exclusion of English language learners¹ (ELLs) from advanced math courses in secondary education (Callahan, Muller, & Wilkinson, 2010; Callahan & Shifrer, 2016; Hanson, Bisht, & Motamedi, 2016; Umansky, 2016a) despite their high prior achievement (Kanno, 2018; Zuniga, Olson, & Winter, 2005) and high aspiration for post-secondary education (Kanno & Kangas, 2014). ELLs' limited access to advanced math courses is problematic as it can lead to a lack of diversity in the future STEM workforce (National Science Board, 2018), which as research indicates, may negatively impact innovation and productivity (Ellison & Mullin, 2014; Hewlett, Marshall, & Sherbin, 2013).

A number of previous studies have sought to uncover disparity in course taking patterns between ELL and non-ELLs, mainly using nationally representative data or administrative data (Callahan et al., 2010; Callahan & Shifrer, 2016; Hanson et al., 2016; Umansky, 2016a). Meanwhile, school practices that limit ELLs' opportunity to learn have been primarily examined by qualitative approaches (Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010; Zuniga et al., 2005). It is rare to find data sets that allow for an examination of patterns between the two, a gap that this dissertation

¹ English Language Learners are widely used in research and policy, but they do neglect the bilingual/multilingual capacities of youth: they are *designated* as ELLs, but these are not identities that the youth themselves may embrace. “Transnational” or “emergent bilingual” students are also used in lieu of ELLs to highlight the capacities of students from immigrant families (Cervantes-Soon et al., 2017).

plans to address. Using a nationally representative data, the High School Longitudinal Study of 2009, the present study examines how three key school practices—student choice-based math placement policies, math encouraging program for underrepresented students, and instructional supports measured by math professional learning communities—correspond to math academic outcomes measured by advanced math courses taken by ELLs across schools. In this chapter, I briefly introduce the study context and the gaps in research on ELLs’ course taking. I present the theory on dimensions of organizational differentiation that informs the conceptual framework of the present study, which is followed by the significance of the study.

Statement of the Problem

In an increasingly knowledge and technology intensive society, the growth for STEM jobs has been outpacing all other occupations over the last two decades (National Science Board, 2018; Pew Research Center, 2018). While knowledge and skills learned in both STEM and non-STEM subjects provide the foundation to prepare students to become part of the STEM-capable workforce, achievement in mathematics is prerequisite to pursue most STEM professions (National Science Board, 2015). Particularly in high schools, taking advanced math courses is predictive of high interest in STEM career (Warne, Sonnert, & Sadler, 2019) and college completion with a STEM degree (Ackerman, Kanfer, Calderwood, 2013; Tyson, Lee, Borman, Hanson, 2007; Wang, 2013).

Whereas there is ongoing debate about the shortage or surplus of the STEM workforce in the United States (National Science Board, 2015), there is almost unanimous consensus about the necessity to diversify the STEM workforce (National

Science Board, 2018). As STEM plays a central role in fostering innovation (National Science Board, 2018), there is a concern about a lack of diversity in the STEM workforce as it may negatively impact innovation and productivity (Ellison & Mullin, 2014; Hewlett, Marshall, & Sherbin, 2013). Underrepresentation of women and ethnic minorities has been a focus of many studies, which also attempt to uncover the barriers faced by members of those groups. Recently, the report from National Academies of Sciences, Engineering, and Medicine (NAS, 2018) highlights ELLs as another underrepresented group in the STEM workforce and stresses the need for policy to boost their participation in STEM careers. The NAS (2018) defines English learners as students whose native language is not English and who receive English language support programs in elementary or secondary schools, which is consistent with the definition in the Elementary and Secondary Education Act (ESEA). Given that the majority of English learners are Latinx students, the NAS (2018) has recently pointed out that the underrepresentation of this ethnic group may be particularly related to their ELL status during their schooling. As ELLs are being identified as “an untapped resource for developing a multi-lingual STEM workforce” (Barrera, 2011), it is important to ensure ELLs’ equal access to advanced math courses in high schools in order to facilitate their participation in STEM workforce in the future.

However, research has indicated systemic exclusion of ELLs from advanced math courses in secondary education. Previous studies showed that ELLs are less likely to access college preparatory coursework that includes advanced math courses in high school (Callahan et al., 2010; Callahan & Shifrer, 2016; Hanson et al., 2016) and also less likely to be placed in academic content area classes such as English language arts, math,

and science in middle school than their non-EL peers (Umansky, 2016a). Those quantitative studies mainly controlled for an extensive set of factors that might account for students' course taking patterns including their socioeconomic background and prior achievement. Thus, their findings suggest that ELLs are consistently denied access to advanced core courses even though they share the similar observed characteristics and achievement level with non-ELLs. Qualitative studies have also documented ELLs' limited access to advanced courses or core-contents area classes (Estrada, 2014; Gándara, Rumberger, Maxwell-Jolly, & Callahan, 2003; Morita-Mullaney, Renn, & Chiu, 2020; Thompson, 2017; Xiong, 2010) despite their high prior achievement (Kanno, 2018; Zuniga et al., 2005) or high aspiration for post-secondary education (Kanno & Kangas, 2014).

Educators exclude ELLs from advanced courses primarily based on their assumption that participation in academically demanding courses are predicated on English proficiency (Kanno, 2018; Kanno & Kangas, 2014; Pettit, 2011; Thompson, 2017; Zuniga et al., 2005; Xiong, 2010). However, scholars have argued that ELLs' participation in rigorous math courses help them develop not just math knowledge but also their English proficiency (Gibbons, 2015; Haynes & Zacarian, 2010; Huang, 2004). The basic idea is that language learning and knowledge acquisition are not separate domains and that students can learn language best when they engage in meaningful contexts of use (Grabe & Stoller, 1997). More specifically, language varies depending on what is being covered (contents), and who is being involved (relationships), and how meaning is being presented via linguistic- and non-linguistic resources (modalities) (Halliday, 1978). These three aspects of a context are called "register" in linguistics,

which is articulated by the linguist Michael Halliday in his seminal discussion on mathematical register (Halliday, 1978; Schlepppegrell, 2007).

The notion of register offers the understanding of how each academic subject functions to expand the linguistic repertoire of all students (Schlepppegrell, 2007). Not just ELLs but also non-ELLs are adding new registers by becoming familiar with math concepts and practices via engaging in these three aspects of contexts (Schlepppegrell, 2007). Especially, the concept of modalities in register gives an insight on how ELLs are capable of engaging in academic content area classes through non-linguistic multiple resources (e.g., gesture, visualization, artifacts, scientific modelling) even though their English proficiency is still developing (Grapin, 2019). Thus, scholars claim that it is imperative to engage ELLs in math contents at a pace similar to their peers to help them gain refined discourse patterns in these disciplines as well as develop their English proficiency simultaneously (NAS, 2018). However, deficit-oriented school practices delay their access to such courses, sometimes in the name of protecting them from too challenging courses (Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Zuniga et al., 2005; Xiong, 2010).

Purpose of the Study

The research has identified multiple school-level factors that are involved in inhibiting ELLs' access to advanced or core courses. First, deficit-oriented course placement practices that equate English proficiency with academic ability primarily affects ELLs' course placement (Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Zuniga et al., 2005). Educators tend to posit that English proficiency should be developed sufficiently before ELLs take academically demanding courses (Gándara & Hopkins,

2010; Harklau, 1994). Second, lack of differentiated instruction to meet the needs of ELLs discourage educators to place ELLs to higher track courses (Kanno & Kangas, 2014). Kanno and Kangas (2014) describe counselors' reluctance to place ELLs in high track classes as they perceive that content area teachers, especially in high track courses, are not ready to accommodate students with various needs. Third, rigid course placement policies, especially the ones which place heavy weight on test scores, basically block ELLs from accessing advanced or higher track courses (Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010). Academic outcomes on tests administered in English may underestimate ELLs' academic ability (Abedi & Lord, 2001; Martiniello, 2008; Parker, Louie, & O'Dwyer, 2009). For instance, ELLs' performance on math tests increases when wording in questions are modified to be more straight forward and simpler than the original test (Abedi & Lord, 2001). Fourth, ELLs and their families tend to have little knowledge on course placement practices and importance of advanced courses, thereby rarely exercising their rights to request for higher-level courses. ELL and their families are particularly disadvantaged in regard to the course decision process and information primarily due to language barrier and unfamiliarity with U.S. school practices (Arias & Morillo-Campbell, 2008; Guo, 2006, Kanno & Kangas, 2014; Xiong, 2010). Lastly, the ELL designation has the cumulative negative effect on their progress under the established sequence of math subjects (Kanno & Kangas, 2014; Thompson, 2017). Math is a more hierarchically sequenced subject than other content areas like English, social science, and science as prior course-taking strongly determines future courses (Adelman, 2006; Oakes 2005). As research has documented, if ELLs take fewer credits of math classes (Estrada, 2014; Umansky, 2016a) or are placed in basic math

course (Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010) in middle or high school, then the sequence of math subjects hardly allows them to take advanced math until the end of high school (Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010).

While several studies have highlighted the unique barriers that ELLs encounter in their course placement process in high school, there exist some gaps to be filled to expand the understanding of what and how school practices/policies are involved in shaping ELLs course-taking trajectories, especially for math. First, school practices that limit ELLs' opportunity to learn have been primarily examined by qualitative approaches using interviews, observations, artifact analysis, etc. While those studies provide invaluable insight on school practices pertaining to ELLs' course placement, a quantitative study is necessary to examine to what extent the findings can be generalizable in broader contexts, using a large dataset. Besides, only a very small number of such qualitative studies have focused on both high school practices and ELLs since the 1990s when there started the nationwide efforts to create more inclusive classrooms in higher track courses across the U.S., which is called "de-tracking" (Harklau, 1994; Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010).

Second, prior research did not specifically focus on course placement policies, although they pointed out cut-off test scores or rare use of course requests as problematic for ELLs' course taking trajectories (Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010). Considering substantial variation in course placement policies across the U.S. high schools (Kelly, 2007), it is important to understand how between-school variation in course placement policies is related to more (or less) equitable access to math courses for ELLs. In particular, student-choice based approaches, e.g., open access policy, has been

widely used as a course placement strategy to ensure more equitable access to higher-track courses such as Advanced Placement (AP) courses for historically marginalized students (Kolluri, 2019; LaPrade, 2011; Pamela, Davis, Mobley, 2014). Thus, examining how student choice-based approaches work with particular conditions of ELLs will expand the knowledge on this commonly adopted de-tracking approach.

Lastly, there is still little understanding of school practices, especially possible practices that can facilitate ELLs' access to advanced math courses because prior research observed mainly institutional barriers. Research on historically marginalized students have documented institutional-level supports such as modified instruction, systemic communication about open access policy, and recruitment efforts in schools that improved enrollment in advanced courses for underrepresented students (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2013). However, little research examines how such school supports may work in the particular situations faced by ELLs as they try to access math courses; especially for modified instruction, most pedagogical endeavors in math education subscribe to the view that learning language and academic contents are inseparable processes (e.g., the review by de Araujo, Roberts, Willey, & Zahner 2018). Examining the instructional support in relation to access to advanced math courses will provide another possible impact that such pedagogical attempts to help produce in ELLs' math course trajectories. In the present study, I seek to fill those gaps in the understanding of ELLs course taking by examining how schools' math course placement policies and other supporting practices can contribute to creating more equitable access to advanced math courses for ELLs.

Research Questions

The present study seeks to understand how student choice-based math placement policies, math encouraging programs for underrepresented students, and instructional supports measured by math professional learning communities are associated with the math course distribution for ELLs, net of their math performance. I utilized the restricted-data from the High School Longitudinal Study of 2009 (HSLs:09). The HSLs:09 is appropriate for the present study as it contains key information on students' ELL status, math courses taken, math assessment scores, along with a rich set of students' backgrounds that have been observed to heavily influence course taking patterns. Most importantly, the HSLs:09 study provides information on math course assignment practices, which is rarely available in large datasets such as state-level administrative data.

The present study drew on the concepts articulated by Sørensen (1970) and prior research on course taking patterns on ELLs and historically marginalized students to make decisions on selecting variables and construct hypotheses. Sørensen (1970) articulated the dimensions of organizational differentiation or tracking, which have helped scholars identify differences in tracking across schools (Domina et al., 2019; Kelly, 2007) and understand a possible mechanism between various levels of tracking and students' outcomes (e.g., Karlson, 2015). Thus, informed by the concepts articulated by Sørensen (1970) and the literature on tracking, I selected two approaches—student choice versus test-based approaches—as contrasting math assigning procedures. The main focus of the present study is student choice-based math placement policy measured by the extent to which a school takes into account student choice in math course placement process. In addition, I examined how instructional supports, systemic

communication about course placement policy, and conscious efforts recruiting underrepresented students are related to ELLs' access to math courses. The present study used math professional learning communities (PLCs) to measure instructional supports; in PLCs educators share expertise and ideas to collaboratively improve teaching and learning including effective practices for ELLs and new teaching approaches for underperforming students (Ingels et al., 2011). Also, the present study used math encouraging programs for underrepresented students as a way to capture the institutional efforts to inform students of their rights to choose higher level courses and recruit underrepresented students into such courses.

Thus, the present study seeks to understand how school practices that are known to facilitate marginalized students' access to higher level courses may influence educational opportunities for ELLs measured by the probabilities of taking advanced math courses during high school. The research questions are as follows:

Q1: How do school practices—student choice-based math placement policies, math encouraging program for underrepresented students, and math professional learning community—relate to ELLs' advanced math course taking net of their prior achievement as well as other student- and school-characteristics predicting their math course taking patterns?

Q2: Do math encouraging programs for underrepresented students have any differential effects on the association between student choice-based math placement policies and ELLs' advanced math course taking?

Significance of the Study

The present study seeks to contribute to the literature on ELL's course taking patterns, an area that is sparsely studied, by examining how student assignment procedures and institutional supports might affect the distribution of their educational opportunities. Research has found that ELLs face inequitable access to rigorous and core content courses due to their triple disadvantage of limited English proficiency, minority, and poverty (Gamoran, 2009). The results of the study will help educators to examine which institutional practices and programs may work against or for improving inclusiveness of this marginalized group of students. In particular, the findings of the present study expand the knowledge base on student choice-based approaches, a commonly used criterion to increase diversity of classrooms in terms of SES, race, and academic abilities in the tracking literature by examining its relationship with another marginalized group, ELLs. It will thereby inform educators of whether choice-based approaches may work for ELLs or how to implement them with a goal to improve inclusiveness.

Chapter 2: Literature Review and Theoretical Framework

Advance math course taking in high schools is known to have a critical impact on students' postsecondary options and professional opportunities (e.g., Ackerman et al., 2013; Byun et al., 2015; Warne et al., 2019). Because of its possible strong impact on educational and professional trajectories of students, math course taking has been used as a measure of equitable distribution of educational opportunities across student groups (e.g., Gamoran, 2009; Haxton & O'Day, 2015; Oakes, 2005). However, the sequential nature of math course structure typically allows little mobility once students have been placed in a math course with a certain topic or level as the previous course taken strongly predicts the subsequent math courses (Kelly, 2007; Stevenson, Schiller, & Schneider, 1994). In this sense, English language learners are situated in a most disadvantageous position in the math course taking; they are often placed in remedial or a lower level math without consideration of their math skills developed in their prior education (Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017). Also, considering their high likelihood to being socioeconomically (American Community Survey, 2008-2012) and racially marginalized students (Hussar et al., 2020), ELLs encounter the institutional barriers that those historically marginalized students have experienced in addition to the unique obstacles that their ELL designation or developing English proficiency triggers. Thus, it is important to look into how policies or programs that schools have chosen in regard to course placement and ELLs may impact their math course taking trajectories in high school.

In the following sections, I first introduce the historical change on the course placement policies in the U.S. high schools, drawing from the academic tracking

literature and relevant studies on Advanced Placement courses. I specifically focus on student choice and its mixed outcomes as a widely adopted strategy to create more diverse classrooms in terms of race, socio-economic status, or perceived academic skills. Subsequently, I focus on ELLs, reviewing their systemic exclusion not just from higher-level courses but also from core content areas, and possible explanations on their unequal course access provided by research on ELLs' course taking trajectories. Next, I discuss the pedagogical endeavors in math education to make challenging math courses accessible to ELLs. At the end of this chapter, I present the theory on dimensions of organizational differentiation and the research gaps that the present study seeks to fill.

Course Placement Policies in U.S. High Schools

Course placement policies in high school have been characterized as ability grouping and tracking, but considerable variation exists among schools in how they select students or put them into particular courses (Gamoran, 2009; Kelly, 2007; Kelly & Price, 2011). After defining ability grouping and tracking in general, this section reviews research on educational practices and policies that attempt to counteract the racial and ethnic segregation that has occurred as schools separate students into courses according to their perceived academic abilities.

Tracking and Ability Grouping

While ability grouping and tracking are often used interchangeably, some scholars draw a distinction to capture schools' and students' course-taking patterns (Yonezawa, Wells, Serna, 2002). Historically, tracking meant the assignment of students to mutually exclusive curriculum such as academic/college-preparatory, general, or vocational within schools and allowed little mobility across the tracks (Lucas, 1999; Lucas & Berends,

2002). This rigid form of tracking declined dramatically in the late 1960s and 1970s under the influence of the civil rights movement as many schools started switching to more flexible policies often called ability grouping, which divided students into different courses on a subject-by-subject basis (Gamoran, 2009; Lucas, 1999; Lucas & Berends, 2002). As empirical studies that analyzed data from the 1980s and 1990s indicated, ability grouping allowed students to take discrepant courses across the different tracks. For instance, a student might take a lower-track course in English Language Arts but concurrently enroll in high-track math courses based on her assumed learning capabilities (Lucas, 1999; Lucas & Berends, 2002; Yonezawa et al., 2002). Despite the increased mobility among tracks, however, many studies conducted in the 1990s found disproportionately high concentration of minority or socio-economically vulnerable students in lower-track courses across subject areas (Lucas, 1999; Oakes, 2005). Thus, scholars claimed that ability grouping worked as *de facto* tracking, which maintained racial or socio-economic segregation within schools (Lucas, 1999; Oakes, 2005).

The scholarship on the tracking has uncovered the way sorting students by perceived academic abilities reinforces social inequality: quality of instruction stratified by tracking and strong association between prior academic achievement and students' family backgrounds. Conceptually, ability grouping is designed to differentiate the curriculum and instruction to meet the needs of students at the varying academic capacity (Alexander & Cook, 1982; Kelly & Price, 2011). This technical perspective justifies assigning students based on their academic achievement, which is often measured by test scores, grades, and/or prior courses. But in practice, high or low track courses often correspond to quality of instruction. Students in high track courses have more challenging

curricula, more experienced teachers, higher teacher expectations (Kelly & Carbonaro, 2012), and more support (Mayer, LeChasseur, & Donaldson, 2018) than their peers in low track courses (for reviews, see Gamoran, 2004). Those elements are known to positively influence student learning.

A number of studies have also documented widening achievement gaps between students assigned in high and low tracks over the course of high school (Penner, Domina, Penner, & Conley, 2014; Long, Conger, & Iatarola, 2012; Lucas & Gamoran, 2002; Potter & Roksa, 2013). Thus, many scholars have claimed that quality of instruction stratified by ability grouping may exacerbate, rather than mitigate, the initial achievement gap among students placed in high and low track courses. Furthermore, because academic measures such as test scores or prior course-taking are highly correlated with socioeconomic status and race/ethnicity, students from marginalized background are disproportionately concentrated in lower track courses (Lucas & Berends, 2002; Clotfelter, Ladd, Vigdor, 2005; Kalogrides, Loeb, & Be'teille, 2013). Therefore, ability grouping has been criticized to reinforce social inequality by sorting students of minority or low SES students into lower track courses which often lack in rigor (Gamoran, 2009; Oakes, 2005; Clotfelter et al., 2005; Kalogrides & Loeb, 2013).

Policy Responses to Segregation Resulting from Course Placement Policies

In response to criticism over de facto tracking, schools and districts have adopted various approaches to increase heterogeneity of students in the classroom in terms of race, SES, and ability-level over the past three decades (Atteberry, Lacour, Burris, Welner, & Murphy, 2019; Domina, Hanselman, Hwang, & McEachin, 2016; Rubin, 2006; Yonezawa et al., 2002). Such efforts are often dubbed as “detracking,” which are

broadly divided into two main courses of actions although they are not mutually exclusive (Kelly, 2007; Rubin, 2006; LaPrade, 2011). One is increasing student choice in course placement decision-making and the other is restructuring the course hierarchy by eliminating ability grouping in a specific subject or even across all the subject areas (Atteberry et al., 2019; Bavis, 2016; Kelly, 2007; Rubin, 2006).

Two studies illuminate these differential approaches (Atteberry et al., 2019; Yonezawa et al., 2002). Yonezawa and colleagues (2002) studied six racially diverse high schools from 1992-1995 across the United States, which voluntarily adopted student choice-based policy as educators were concerned about the high concentration of Latinx and Black students in low- and middle-track courses. Still maintaining the hierarchy of courses such as general versus honor classes, those schools granted students options to choose higher-level courses by mitigating or reducing course prerequisites such as previous courses, grades, or teacher recommendations (Yonezawa et al., 2002).

In contrast, a suburban high school studied by Atteberry and colleagues (2019) analyzed an example of de-tracking measures that dismantled hierarchical course structures in all subjects. The reform efforts were initiated by the district to increase enrollment in International Baccalaureate (IB) courses that had been exclusively provided for a small number of students labeled as “gifted” (Atteberry et al., 2019). Starting in 1999, the only high school in this small district in the state of New York introduced mixed-ability classes, first in English and social studies and finally science and math, to prepare all 11th and 12th graders to enroll in IB program.

This latter form of de-tracking, the complete elimination of ability grouping in all subject areas, is quite rare in high schools; it has often faced resistance, not only from

white parents and those of a more privileged backgrounds (Wells & Serna, 1996; Wells & Oakes, 1996), but also from teachers who believe it difficult to teach mixed-ability classes (Gamoran, 2009; Loveless, 1999). In contrast, the choice-based approach has widely been adopted as a de-tracking tool as this strategy has experienced less political upheaval that often accompanies eliminating the course hierarchy (Yonezawa et., 2002, Gamoran, 2009). Therefore, as a response to the nationwide de-tracking reforms which started in the early 1990s, student choice has been incorporated into course placement criteria along with the historically established ones such as academic achievement and teacher/counselor recommendation (Atteberry et al., 2019; Bernhardt, 2014; Kelly, 2007; Rubin, 2006). While student choice has widely been employed to create more diverse classrooms, research suggests that de-tracking efforts have achieved only partial success as the gaps in high track course enrollment along the line of race and SES remain persistent although marginalized students' enrollment in higher track classes has increased some, as discussed in the following sections.

Student Choice as a Strategy to Create Diverse Classes. The central purpose of adopting choice-based approaches is to provide more equitable access to rigorous courses by reducing academic requirements and allowing students' latitude in making course decisions. Research has shown the increased participation of racially or economically marginalized students in AP courses and other advanced courses since the 1990s when nationwide de-tracking reforms started (Judson & Hobson, 2015; Kettler & Hurst, 2017; Rodriguez & McGuire, 2019). However, most of those studies also indicate that the gaps in high level courses enrollment between Black/Latinx and White students have been persistently maintained over time (Kettler & Hurst, 2017; Rodriguez & McGuire, 2019).

Moreover, despite some increase in enrollment based on student choice, overall marginalized students are still underrepresented in the highest level courses (Domina & Saldana, 2012; Lucas, 1999). For instance, AP's open access policy had no improvement on marginalized students' access to AP courses, net of academic achievement (Corra, Carter, Carter, 2011; Rodriguez & McGuire, 2019). Thus, the de-tracking efforts over the last three decades have only partially achieved the goal of more inclusive access to high track courses. In summary, persistent enrollment gaps and equitable access to high track courses may not be solved by student choice alone. Research suggests a number of institutional barriers as well as organizational supports to address those barriers.

Institutional Barriers Hindering Self-Selection into Advanced Courses.

Research has documented institutional barriers that inhibit underrepresented students' access to higher track courses within the schools that have adopted student choice for their course placement policy. First, course placement information is unevenly distributed from schools to students, often proportional to their racial or socio-economic position in a larger society (Yonezawa et al., 2002 cite). For example, Latinx/Black or low-income students in six racially diverse high schools studied by Yonezawa and colleagues (2002) received limited or little information on their course options to enroll in AP courses or to petition for honor courses. They also found that the way information was disseminated worked to the disadvantage of families who lived in predominantly minority- or low income neighborhood: There were few systematic processes designed to provide information on course options to students or parents; they were mostly informed of their course options via neighborhood network or word-of-mouth (Yonezawa et al., 2002). Counseling departments held sessions to convey the open access policy but often upon

the demand of parents of high income or white parents whereas families from minority or low-income background were less engaged in such sessions (Yonezawa et al., 2002).

Second, a knowledge gap on course placement processes also affects how parents support their children in navigating access to advanced courses (Darity et al., 2001; Lewis & Diamond, 2015; Yonezawa et al., 2002). Parents who are aware of their right to override the recommendation of teachers or counselors readily request for advanced courses for their children (Lewis & Diamond, 2015), whereas minority- or low-income parents tend to acquiesce to schools' decisions (Yonezawa et al., 2002). Furthermore, research has shown that educators respond to course request differentially based on students' race and socio-economic status (Darity et al., 2001; Lewis & Diamond, 2015; Yonezawa et al., 2002). Lewis and Diamond (2015) who investigated a racially diverse, affluent suburban high school provided ample examples where educators readily accommodated the course request made by white parents while resisting the similar request from minority parents. Those researchers found that the course decision process operated with implicit bias against Black or Latinx students: Educators' low expectations of not just performance but also parental involvement contributed to their inaction or denial to course request of minority parents or students (Lewis & Diamond, 2015). Conversely, counselors or teachers more actively met the demands from white students not just because they actually experienced repeated calls from white parents but also because they likely expected the potential pressure from them even without their complaints filed (Lewis & Diamond, 2015). Yonezawa and colleagues (2002) dubbed those differential parent-educator interactions along the line of race, socio-economic status, track-level as "selective flexibility," which is recurring phenomenon also reported

by the most recent studies (Lewis & Diamond, 2015).

The last barrier documented by the empirical research is prerequisite requirements. Despite the open access policy, prerequisites considerably restrict students' latitude in making course decisions. Kelly (2007) analyzed curriculum guides from 92 high schools in North Carolina in the 1997-98 school year. Although course placement processes were often described as "student/parent informed choice" (p. 21) in North Carolina, there were a plethora of prerequisite requirements including previous course-taking, grades, test scores, and teacher recommendation stated in curriculum guides (Kelly, 2007). Thus, Kelly (2007) pointed out that under such restrictions, choice was construed in a very narrow sense as having options within their eligibility. Even schools that promote open access policy without stated prerequisites often impose requirements in various forms. Teachers in the study of Yonezawa and colleagues (2002) promoted open access to their honor math or AP English courses, but they also required previous courses or screening tests as prerequisites. Thus, technically students could enroll in any course but in practice they first should be eligible in terms of academic performance. Data from Kelly (2007) and Yonezawa and colleagues (2002) are from the 1990s and might be outdated, but "hidden prerequisites" (Yonezawa et al., 2002) are still persistently found in the more recent studies and take on subtler forms (Kolluri, 2019).

On top of institutional barriers, underrepresented students' self-selection into low track courses also complicate the effect of choice-based approaches to create inclusive courses. Students in low track courses choose to remain in their current level often because they doubt their ability to compete in more challenging courses or want to avoid racial/social isolation from their peer groups (Darity et al., 2001; Klopfenstein, 2004a;

Tyson, 2011; Walker & Pearsall, 2012; Yonezawa et al., 2002). Although lack of confidence and racial/social identity with their peers appear to be personal characteristics or individual preference, it would be too simplistic to attribute them entirely to individual factors. It should be noted that those students are more likely to have been exposed to less rigorous classes since the beginning of their schooling. For instance, Darity et al. (2001) examined enrollment pattern in advanced courses like gifted, honor, and AP by race from elementary to high school in North Carolina. Analysis of student interviews suggested that students who had not experienced challenging curriculum in the early grades were more reluctant to take advanced courses in high school as they were concerned about heavy workloads. Further, those high school students were content with their current placement, where they thought they belonged. Tyson (2011) who conducted interviews and surveys of students from elementary to high school provides another example of minority students' tendency to choose the courses where they feel socially and academically secure even from elementary school, which subsequently leads to fewer enrollment in AP courses in high school. As the ability grouping starts as early as in the kindergarten or lower elementary grades (e.g., Lleras & Rangel, 2009; Tach & Farkas, 2006), few opportunities to access challenging courses partly contribute to shaping minority students' lack of confidence in their academic abilities and self-selection into lower courses (Darity et al., 2001; Klopfenstein, 2004a; Tyson, 2011). Thus, students' perception of their ability and desire to belong to their peer groups along with institutional barriers complicate choice-based approaches as an effective de-tracking strategy.

Organizational Supports Boosting Student Choice into Advanced Courses.

While student choice alone does not necessarily lead to inclusive classrooms, the success stories documented by other studies indicate that systemic communication about enrollment policies, conscious efforts to recruit underrepresented students into higher track courses, and awareness of achievement gap may lead to achieving more inclusive, higher track classrooms (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014).

One study by Kolluri (2019) has illuminated the critical role that administrators and educators can play to surmount institutional obstacles and change students' perception of their abilities. Kolluri (2019) purposefully chose to examine very successful schools where both enrollment and performance in AP courses over the period of 2011 to 2017 had substantially increased among minority and socioeconomically disadvantaged students. In one school serving 90% Latinx and 90% low-income students, the cooperation among educators stood out. Administrators and teachers ensured that students were fully informed of the open access policy about AP courses by explicitly saying "You have the right to fail" (p. 121, Kolluri, 2019). In addition, teachers had conversations with struggling students to encourage them to take AP courses regardless of their ability level. Furthermore, rather than stressing individual performance, classroom instruction was organized around student-engaged discussion and group works, which facilitated support and collaboration among students, preventing students from being left out regardless of their ability level. LaPrade (2011) also documented several cases of schools that improved underrepresented students' enrollment in higher track courses by raising awareness of achievement gaps and taking conscious efforts to recruit those students for more rigorous courses. Thus, schools that enjoy the increased enrollment in advanced courses of minority or lower-SES students systemically

communicate about open access policy with students, encourage students who show lack of confidence, and modify instruction to help students engaged in classroom regardless of ability level. Thus, empirical evidence indicates that choice-based approaches should be accompanied with additional organizational support to achieve diversity of classrooms in terms of race, SES, and ability-level.

In the next section, I dive into one area that's researched relatively less; the course taking patterns of one marginalized group, English language learners (ELLs). The Elementary and Secondary Education Act (ESEA) defines ELLs as students whose native language is not English and who receive English language support programs in elementary or secondary schools. The prior research on tracking and ability grouping typically has not addressed their particular situation. The research that does exist on ELLs' course taking patterns has reported institutional constraints that overlap those found in studies on historically marginalized students. This overlapping might arise from the fact that ELLs are more likely to belong to historically marginalized students than their non-ELL peers. However, their developing English proficiency and ELL status create additional structural barriers to access to not just higher-level courses but also core content areas.

Systemic Exclusion of ELLs from Core Contents Areas and Advanced Courses

Scholars have pointed out that students designated as ELLs are another marginalized group, who face inequitable access to rigorous courses due to their exposure to triple disadvantage of limited English proficiency, race, and poverty (Gamoran, 2009). The demographic makeup of ELLs in the United States is diverse in terms of language, race/ethnicity, and SES (NAS, 2017). However, ELLs are more likely to have racially,

socioeconomically marginalized backgrounds than their non-ELL peers. The most recent data from National Center for Education Statistics shows that 10.1%, or five million students in the U.S public schools were ELLs in fall 2017. At that time, Latinx (or as Census data still denote, ‘Hispanic’) students consisted of over three-quarters (76.5%) of total ELL enrollment followed by Asian (10.7%), White (6.6%) and Black students (4.3%) (Hussar et al., 2020). Also, data from the American Community Survey (2008-2012) showed that 65% of ELLs are eligible for subsidized school lunches, compared with only 36% of non-ELLs (NAS, 2017). The percentage of ELLs tends to be smaller in higher grades but there is still a portion of ELLs in high school consisting of 7% to 4.6% of total enrollment of 9th to 12th graders (Hussar et al., 2020).

In this section, I review the systemic exclusion of ELLs from both higher-level courses and core academic content areas such as math and science. The limited access to core academic subject courses is uniquely observed in ELLs’ course taking patterns (Callahan & Shifrer, 2016; Estrada, 2014; Gándara et al., 2003; Umansky, 2016a). After examining the enrollment gaps in higher level and academic contents courses between ELLs and their non-ELL peers, I delineate constraining school practices identified by prior research specifically focusing on ELLs.

ELLs’ Course Taking Trends: More Lower Tracks and Fewer Core Content Courses

As expected from findings reviewed in the previous section, research on ELLs’ course taking patterns has also identified overrepresentation in lower track courses (Callahan et al., 2010; Estrada, 2014; Gándara et al., 2003; Hanson et al., 2016; Umansky, 2016a; Zuniga et al., 2005). What is noticeable in ELLs’ course taking patterns

is that ELLs are not only highly concentrated in lower track courses but also less likely to enroll in core academic content areas than their non-ELL peers (Callahan & Shifrer, 2016; Estrada, 2014; Gándara et al., 2003; Umansky, 2016a). Quantitative studies have shown that prior achievement may sometimes explain the baseline gaps in advanced course enrollment between ELL and non-ELL status; however, the observed disparity in core academic subjects consistently remains significant even with achievement controls (Callahan & Shifrer, 2016; Hanson et al., 2016; Umansky, 2016a).

For example, Callahan and Shifrer (2016) analyzed data from the nationally representative Educational Longitudinal Study of 2002 (ELS:2002) to examine two outcomes in ELL course taking patterns in high school: (1) completion of basic graduation credits in English, social studies, mathematics, and science, and (2) completion of college preparatory courses, specifically Algebra II or beyond in math, at least two main science courses, and two foreign language courses. The present study accounted for a wide set of linguistic, social, and academic backgrounds that might explain course-taking outcomes such as English proficiency, SES, prior course-taking in math and science, GPA in core courses, reading standardized test scores. The disparity between ELLs and non-ELLs remained significant for both course-taking outcomes, even after accounting for student and school characteristics that might explain those outcomes.

While Callahan and Shifrer (2016) examined core academic subject areas regardless of track-levels, Hanson et al. (2016) mainly focused on advanced courses—honor, AP, IB, and dual-enrollment—regardless of subject areas when analyzing advanced course-taking patterns of high school students in Washington state. Once they controlled for prior achievement measured by their GPA and standardized test scores in

math and reading, the observed gap in advanced course credits disaggregated by ELLs and non-ELLs disappeared; this suggests that high track courses were assigned based on prior performance. However, over-representation of ELLs in remedial courses is not explained by prior performance. Their descriptive analysis found that ELLs tended to enroll in remedial courses designed for academically struggling students such as algebra support classes and writing labs in far higher rate than non-ELLs. This tendency was still detected among high achieving ELLs, who took far more remedial classes than their non-ELL peers even with similar GPA and standardized test scores in math (Hanson et al., 2016).

Meanwhile, Umansky (2016a) analyzed course-taking patterns of middle school students in one urban school district in California and found that nearly half of ELLs did not enroll in academic subjects—English language arts, math, and science—compared with less than 5% of non-ELLs. This baseline gap in core content credits disaggregated by ELL and non-ELL status still held even controlling for an extensive set of student variables including prior achievement and using school-fixed effect; ELLs with similar standardized test scores and backgrounds took fewer credits in core contents than their non-ELL peers regardless of their school contexts. In contrast, the observed gap in honor course credits between ELLs and non-ELLs was mostly explained by standardized test scores. Umansky (2016a) called this limited access to core contents areas as *exclusionary tracking* to distinguish it from the traditional notion of tracking.

The exclusionary tracking has been documented by other prior research that closely looked into students' transcripts. Estrada (2014) examined ELL course placement policies in four California middle schools and found that ELLs' class schedules mostly

consisted of few or no core contents classes, remedial and English language support classes, both of which did not serve academic purpose. Even high-achieving ELLs could not as fully access to academic subjects as their non-ELLs did (Estrada, 2014; Morita-Mullaney et al., 2020). Gándara and her colleagues (2003) who examined transcripts of high school students from two California school districts also found the similar course placement patterns; ELLs' class schedules showed multiple empty class periods, remedial classes, too many electives while having few or no core contents areas, especially science. Thus, empirical research indicates that ELLs may face constrained access to not just high track courses but also academic subjects.

School Practices Constraining ELLs' Access to Advanced Courses

Research providing in-depth look on ELLs' course placement process has unraveled problematic practices and course structures that hinder their access to higher-track courses as well as core academic subjects. As ELLs likely belong to other marginalized groups of students in terms of their race/ethnicity or SES, the obstacles that they encounter at schools share the features found by research on historically marginalized students: Lack of systematic information delivery, lower involvement in course decision making, implicit bias embodied in responses to course request, and prerequisites precluding access to higher-track courses. However, their ELL designation exacerbates those issues and also creates additional obstacles that other groups of students may not experience.

Deficit Orientation Equating English Proficiency With Academic Ability.

ELL designation triggers deficit orientation where educators tend to associate limited English proficiency with academic abilities and assume that ELLs are not ready for fully

participating in academic subjects (Callahan, 2017; Gándara & Hopkins, 2010; Harklau, 1994; Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Zuniga et al., 2005). Generally, deficit thinking is to perceive a particular group of students as having an inherent deficit (Flores, Kleyn, & Menken, 2015). Through a deficit lens, ELLs' limited English proficiency is viewed as a significant disadvantage, even "disability" (p. 50, Harklau, 2000). Such deficit thinking prevents educators from recognizing ELLs' linguistic competence as emergent bilinguals and their academic and cognitive skills developed through their prior education. Kanno (2018) highlights how deficit orientation barred high achieving ELLs from transitioning to college preparatory courses despite their high GPA and aspiration for four-year college. In this study, the suburban high school located in a working-class community placed ELLs on ELL-sheltered courses specifically designed for ELLs or low-track courses (Kanno, 2018). Even when ELLs were able to exit from ELL sheltered courses, they were automatically placed into low-track courses regardless of their academic performance. Her previous study on the same school with her colleague documented that teachers and educators unequivocally stated that ELLs would be incapable of handling demanding workloads of reading and writing expected in high level courses (Kanno & Kangas, 2014). Zuniga and colleagues (2005), who examined one rural high school, also revealed something similar: ELLs were placed into science courses intended for students diagnosed with learning disabilities. Even ELLs who performed over average on standardized reading tests and GPA also tended to be placed into low track science despite their strong aspiration for college. The mismatch of their demonstrated academic performance and course placement subsequently limited their access to college preparatory courses despite their high aspiration for four-year

college (Kanno, 2018; Zuniga et al. 2005). The most concerning findings are that ELLs who still felt insecure about their English proficiency internalized these deficit orientations, perceiving their placement in remedial or low track courses as their capabilities and lowered their aspiration over the course of high school years (Gándara & Orfield, 2012; Kanno, 2018; Kanno & Kangas, 2014). Along with the deficit-oriented tracking practices, the ELL programs that are provided with a goal of creating equitable educational opportunities may lead to limiting their access to core contents and higher-level courses.

Unintended Effects of ELL Support Programs. The English language support programs such as English as a second language (ESL) classes intend to serve ELLs' linguistic needs but may produce unintended negative impacts on their academic trajectory (Dabach & Callahan, 2011). For example, Callahan and colleagues (2010) using the Educational Longitudinal Study of 2002 (ELS:2002), which followed a nationally representative sample of sophomores from 2001–2002 school year, analyzed the course taking patterns among language minority students who were defined to speak a language other than English at home. They compared two groups of those language minority students—students in ELL classes and those not—who shared the similar level of English proficiency and other characteristics using the multi-level propensity score matching techniques. They found that placement in ELL classes during high school was related to decreased access to high level math and core science courses and that only ELLs who recently arrived in the US with the lowest levels of English proficiency benefited from ELL support service. Similarly, Umansky (2016b) utilized the cutoff scores used to assign language minority students to ELL service in an urban school

district in California when students entered the kindergarten and followed their academic trajectory up to tenth grade. Using a regression discontinuity strategy, assuming that language minority students just above and below the ELL cutoff scores were comparable, Umansky (2016b) found that ELL designation in the kindergarten produced negative effect on math and English standardized test scores in second grade to tenth grade. Those findings indicate that among language minority students with advanced English proficiency, ELL programs may have negative effects on academic outcomes.

Scholars have pointed out that the poor implementation of ELL language and other support programs and their quality of instruction result in producing negative effects of such programs, which are supposed to help ELLs access to academic contents (Hakuta, 2011; Ovando & Collier, 1998). ELLs programs should not supplant academic subject courses but in practice ELL programs occupy a portion of their course schedule, crowding out core contents courses as documented by studies (Estrada, 2014; Gándara et al., 2003; Morita-Mullaney et al., 2020; Umansky, 2016a).

Especially, scholars have persistently pointed out the poor quality of instruction not just in ELL language support programs but also in ELL sheltered subject area classes specifically designed for ELLs (Dabach, 2015; Estrada & Wang, 2013; Harklau, 1994). Research shows that ELL sheltered subject courses often feature less rigor and depth of content and slower pace and are taught by less experienced teachers than general education classes (Dabach, 2015; Estrada & Wang, 2013; Harklau, 1994).

Dabach (2015) who investigated into teacher assignment processes at seven high schools in California found that ineffective teachers in terms of experience and management skills were more likely to be assigned to ELL sheltered courses. The senior

teachers who had privilege to choose courses often tended to avoid ELL sheltered courses. So, those courses were often only options left for novice teachers, who are typically known to be less effective than their senior colleagues (Clotfleter et al., 2005; Darling-Hammond, 2000). Also, teachers with classroom management issues were often assigned to ELL sheltered classes as administrators perceived that immigrant families would not complain about the school decision. Those teacher sorting practices can negatively affect student learning as teacher quality is known to influence students' academic, behavioral, and even future economic outcomes (Chetty, Friedman, & Rockoff, 2011; Jackson, 2012). Even teachers in higher-level courses are not well-prepared to serve the needs of ELLs, which makes educators further eschew placing ELLs in challenging courses.

Lack of Differentiated Instruction in Advanced Courses. The lack of differentiated instruction in advanced courses steers educators away from placing ELLs into high track courses (Kanno & Kangas, 2014). In general, ability grouping is so embedded in high school course structures that few teachers are prepared for instructing students of varying abilities or needs in one classroom (Gamoran, 2009). Counselors in the study by Kanno and Kangas (2014) cited teachers' lack of differentiated instruction in high level courses as a reason to avoid placing ELLs in those classes. Research on the tracking or ability grouping in general student population also suggests that this technical challenge of teaching mixed-ability classes is a major impediment to creating inclusive classroom (Gamoran, 2009; Loveless, 1999; Rubin, 2006). Teachers who believe that they are not equipped to teach students with a widely varying levels of performance often resist mixed ability classrooms.

Test Scores Downwardly Biasing Against ELLs. Course placement policies that require prerequisite, especially test scores, considerably deter ELLs from accessing advanced or high-level courses (Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010). High track courses such as honor or AP courses often require academic performance such as state standardized test scores (Kanno & Kangas, 2014), a good grade in previous courses (Thompson, 2017), or placement test scores (Xiong, 2010). As ELLs' academic achievement on average is far lower than their non-ELL peers, academic performance, especially test scores, are an inhibitor to accessing high track courses (Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010). Also, the high track courses often require demonstrated strong reading/communication skills regardless of subject contents areas, which works to disadvantage of ELLs who are still developing English language skills (Kanno & Kangas, 2014).

More importantly, academic outcomes on test administered in English may underrate ELLs' academic capabilities (Abedi & Lord, 2001; Martiniello, 2008; Parker et al., 2009). The word modified math tests administered by Abedi and Lord (2001) is an illuminating example. They purposefully selected and simplified math items containing complex words, phrase, or structures from the National Assessment of Educational Progress mathematics assessment (Abedi & Lord, 2001). By randomly assigning two sets of tests with original and simplified versions to 1,174 eighth-grade students within the same classroom, the researchers found that, while overall students benefited from simplified version of math tests, ELL, low-SES, and low math track students gained far higher than their counterparts (Abedi & Lord, 2001). Another study by Martiniello (2008) who examined Spanish-speaking fourth grader ELLs using the state math standardized

tests also detected the pattern that ELLs tended to answer math questions incorrectly due to their misinterpretation of or unfamiliarity with linguistically complex test items although they already understood the concepts. Thus, empirical research suggests that test outcomes administered in English may be downwardly biased against ELLs, further impeding their access to high track courses, particularly when more rigid course placement policies requiring academic performance are implemented.

Little Knowledge on Course Placement Practices and Importance of Advanced Courses. Research on ELLs' course taking patterns has found that ELLs tend to acquiesce to the course recommendation provided by their schools. This tendency and its reasons are similar to those found by research on marginalized students' course taking patterns: ELLs and their parents are poorly informed of course placement policy and subsequently rarely exercise their rights to request for higher-level courses. However, ELLs and their parents are doubly disadvantaged in this regard because of; i) their lack of understanding importance of advanced courses for postsecondary options, ii) language barrier, iii) unfamiliarity with U.S. school practices, and iv) cultural difference that rarely challenges school decisions out of respect for educators (Guo, 2006, Kanno & Kangas, 2014; Xiong, 2010). Although the studies on ELLs course taking patterns did not specifically focus on choice-based approaches, all participating schools in those studies had student choice as one of their course selection criteria. However, ELLs and their families rarely used those options except choosing electives (Kanno, 2018; Kanno & Kangas, 2014; Thomson, 2017). ELLs in the study by Kanno and Kangas (2014) had not realized the importance of advanced courses for their postsecondary options until the end of high school. Only after they had gone through college applications did they regret

taking ELL sheltered or remedial course which did not help them to get to four-year college or majors that they wanted to. Immigrant parents who themselves had no experience in the U.S. schooling also often are unable to provide appropriate guidance on course-selection for college planning (Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010).

On top of having little grasp of academic tracking and its implications on college choice, ELLs and their families have little knowledge about course decision policy and tend to accept school recommendations even though they are not binding (Kanno & Kangas, 2014). Even when ELLs know about their rights and request a different course, it works in a way to jump down the course levels, rather than jump up; ELLs' request for lower-level courses are readily honored, whereas their request for higher-level courses often encounter resistance from counselor and teachers (Thompson, 2017; Xiong, 2010). For example, Xiong (2010) who examined the experience of Hmong American ELLs documented a case where a student's request to switch from an ESL course to a college preparatory English was rejected by a counselor despite his straight A grades in all courses. Consequently, he remained in ESL courses until graduation. In contrast, studies discovered the pattern that ELLs' request to switch to lower courses, e.g., from honor math to regular, were met with little resistance (Thompson, 2017). Research also highlights how language barrier makes immigrant parents further eschew interactions with the school (Kanno & Kangas, 2014). Despite their strong aspirations for college degree for their children, immigrant parents tend to avoid contacting counselors/teachers or participating in school information sessions because of their language barrier (Kanno & Kangas, 2014). Also, even they detect issues with children, they convey their

expectations via their children to their school (Kanno & Kangas, 2014). Although parents are involved in course decision process, the language barriers put immigrant parents in a very vulnerable position to negotiate the coursework (Kanno & Kangas, 2014).

In addition to the language barrier, the cultural norms that often respect educators' decision further discourage them to negotiate the recommended course schedule (Kanno & Kangas, 2014). Intervention and negotiation to advocate for their children are shared practices, especially by the U.S. middle class parents (Horvat, Weininger, & Lareau, 2003). However, many immigrant parents perceive those practices as disrespect for educators' decisions and are reluctant to assert their request (Arias & Morillo-Campbell, 2008; Guo, 2006). Those findings offer understanding about why ELLs and their families accept school's decision and rarely use choice criterion of course taking policy.

In the next section, I transition from the overall ELL's course taking patterns to their math education, specifically focusing on math course taking as a measure of equitable educational opportunities, and its importance in ELLs' educational outcomes and English language development. I also delve into math course structures, which stratify the learning opportunities, further limiting ELLs' access to rigorous courses, which are often are advanced or high-level math courses.

Math Course Structures and Instructional Supports for ELLs

The preceding section delineated school practices limiting ELLs' access to advanced courses including math. This section specifically focuses on math education, especially math course structures and pedagogical supports for ELLs in math classes. After briefly exploring possible impact of taking rigorous math courses on ELLs' life trajectories, I discuss how highly elaborated math course structures fundamentally stratify

the learning opportunities, net of students' math performance. Then, I introduce the social-linguistic approach that views learning language inseparable from learning academic contents, and pedagogical endeavors that tap into this changed view and attempt to incorporate non-verbal resources and students' first language into math instruction.

Importance of Rigorous Math Courses on Students' Life Trajectories

Math course taking in high school is known to have a considerable impact on students' educational and professional trajectories. There is ample evidence from research that math course-taking in high school is closely related to students' math performance and college enrollment (e.g., Byun et al., 2015; Chajewski, Mattern, Shaw, 2011; Godfrey, Wyatt, Beard, 2016). Research also has found positive relationships between advanced math course-taking and future earnings (Joensen & Nielsen, 2009; Rose & Betts, 2004), increased interest in STEM careers (Warne et al., 2019), and higher probabilities of STEM major completion in college (Ackerman et al, 2013; Tyson et al., 2007; Wang, 2013). Because of its considerable impact on postsecondary and professional opportunities, researchers have used math course taking as a measure of how equitably educational opportunities are distributed across various groups of students (Gamoran, 2009; Haxton & O'Day, 2015; Lucas, 1999; Lucas & Berends, 2002; Oakes, 2005).

Math course taking is a particularly important issue for ELLs, not just as a measure to examine equitable educational opportunities but also as a crucial predictor for their participation in STEM areas in the future. The National Academies of Sciences, Engineering, and Medicine (NAS, 2018) has recently attributed the underrepresentation

of Latinx in the SETM workforce to their ELL status during their schooling, and their limited access to rigorous math and science courses. The National Science Foundation (NSF), a U.S. federal science agency, has also stressed increasing access to advanced math courses among ELLs to diversify future STEM workforce based on research findings that the diverse workforce is one of critical factors to boost innovation and productivity (National Science Board, 2018). However, the highly elaborated math course structures—in terms of topic sequences and ability grouping levels—create additional barriers to ELLs in accessing advanced courses.

Hierarchical and Sequential Organization of Math Courses

Sequential and hierarchical nature of math courses often limits access to advanced courses for underrepresented students who tend to be less academically prepared when they reach high school (Kelly, 2007; Stevenson et al., 1994). Math courses typically follow a linear sequence of topics where students are supposed to master certain concepts and skills in order to study more advanced materials (Kelly, 2007; Stevenson et al., 1994). For example, if students want to take pre-calculus, they need to have taken both algebra II and geometry (Kelly, 2007). Furthermore, math courses are highly differentiated by ability grouping within the same topic (Stevenson et al., 1994). For example, the high school involved in the study by Thompson (2017) provides four different levels of Algebra I: two courses for special education students, one sheltered course for ELLs, general, and honors. The courses at the varying levels within the same topic differ in their content coverage and pace (Burkam & Lee, 2003). Also, the same topic like Algebra I is spread over two academic years with reduced rigor or pace as a course title like Algebra Part I and Part II (Burkam & Lee, 2003). Thus, these sequential

and hierarchical organizations of math function together to determine the future courses. In other words, a student's starting position in terms of math topic sequence and ability level considerably determine the highest math course that she can take at the end of high school. For example, a high performing ELL in the study by Kanno and Kanga (2014) started with regular Algebra 1 and Geometry in the tenth grade—which is called “double up,” taking two math courses in one year—when she first started U.S. schooling. Subsequently, she took a regular Algebra II and ended up with regular College Algebra in her senior year. Her starting position in math course in the tenth grade hardly allowed her to take pre-calculus, which was the more advanced course than College Algebra in terms of the topic sequence.

This positional advantage/disadvantage in math has been discovered by a number of studies on general student population (Kelly, 2007; Stevenson et al., 1994). The level or topics of math that students take in the eighth grade strongly predict the highest math that they take at the end of high school, net of their academic performance (Stevenson et al., 1994). Particularly, taking Algebra I in the eighth grade is critical to accessing advanced math courses in high school (Gamoran & Hannigan, 2000; Stevenson et al., 1994). The sequential and hierarchical organizations of math courses create additional structural barriers to ELLs. Placing ELLs in remedial or ELL sheltered math classes without considering their prior learning may produce one more bar to jump up to take advanced math courses in high school.

This structural issue may not be easily addressed unless educators are trained to provide instructional support to engage ELLs in challenging math courses. The lack of differentiated instruction in advanced courses is one of main reasons that educators are

reluctant to place ELLs in advanced courses, sometimes in the name of protection (Kanno & Kangas, 2014). This technical issue is also identified as one main obstacle to persuade educators to create a mixed ability class in the literature on tracking (Gamoran, 2009; Loveless, 1999; Rubin, 2006). Recently, scholars in math education endeavor to engage ELLs in math classes by modifying their approaches to math instruction. In the following, I introduce the changed view on language learning, which stresses the importance of taking rigorous academic courses in developing English proficiency, and pedagogical attempts to help ELLs engage in math classes by tapping into verbal- and non-verbal multiple resources.

Language Development and Rigorous Academic Courses

Recent scholarship in ELL education supports the notion that learning language and mastering disciplinary concepts are not separable domains and that engagement in rigorous academic courses is a key to developing English proficiency as well as subject contents understanding (Haynes & Zacarian, 2010; Lee, Quinn, Valdés, 2013; Moschkovich, 2015). This perspective reflects the shift of the second language learning approach: Traditional views emphasized learning discrete vocabulary (lexicon) or grammar (syntax), but more recent approaches view language as meaning-making practices acquired through engagement in social contexts (Larsen-Freeman, 2007; Zuengler & Miller, 2006)—including advanced content courses. This contemporary perspective views language use occurring in real situations or contexts as fundamental to learning process and supports the idea that students can acquire language best when participating in meaningful contexts of use (Zuengler & Miller, 2006). More specifically, scholars in the social-linguistic approach often draw on the concept of linguistic register,

which is articulated by the linguist Michael Halliday in his seminal discussion on mathematical register (Halliday, 1978; Schleppegrell, 2007).

Register refers to the ways people utilize linguistic and non-linguistic sources depending on i) what kinds of topic, activity, or disciplines are involved (content), ii) who interacts with whom in terms of role, status, or formality (relationship), and iii) what mode of communications are being used such as gesture, drawing, or varieties of languages (modalities) (Halliday, 1978). The concept of register offers the understanding about the connection of language learning and academic contents areas; learning academic contents is not just obtaining academic knowledge but also expanding their linguistic repertoire by engaging in different subject areas, interacting with different kinds of teachers or peers, and using various modes of communications available, in the process of making sense of academic disciplinary concepts (Halliday, 1978; Schleppegrell, 2007). This approach highlights that ELLs' needs are not distinct from learning academic contents and that learning English and academic contents are neither separate nor sequential processes.

The recent review of math education also suggests that scholars and educators have embraced this idea of integrating language and contents and developed classroom practices and teacher professional development accordingly (see review by de Araujo et al., 2018). Especially, the construct of modalities has informed scholars and educators of how to engage ELLs in disciplinary practices by deploying linguistic and non-linguistic multiple resources (Grapin, 2019). Modalities refer to the way meaning is presented in linguistic (e.g., oral/written language) as well as non-linguistic modes (e.g., gestures, images, charts, tables, or symbols) (Bezemer & Kress, 2008). Researchers have attempted

to incorporate various modalities into math instruction to support ELLs' math learning, emphasizing visual representation (e.g., Crawford, 2013; Freeman, 2012; Warren, & Miller, 2015) or capitalizing on their first languages (e.g., Dominguez, 2011; Rubinstein-Ávila, Sox, Kaplan, & McGraw, 2015). The findings of those studies indicate that the use of multi-modalities can boost ELLs' gaining mathematical knowledge and benefit non-ELL students as well (Warren, & Miller, 2015). Modified instruction utilizing multiple resources and its positive results in ELLs' performance provide a promising means to make challenging courses accessible to ELLs. In the next section, I delineate a conceptual framework to build hypotheses to test findings from prior research on ELLs course taking trajectories and present the research questions for the present study.

Theoretical Underpinnings

Research on ELLs' course taking patterns has observed an array of school practices that likely constrain their access to higher-level or core contents subjects including math. However, it is still unclear how between-school variation in course placement policies is related to the creation of more inclusive classes for ELLs. Prior research on ELLs' course-taking trajectories did not specifically focus on course placement policies, but rather unraveled institutional barriers in the multiple domains including rigid placement practices placing strong emphasis on academic performance as one of them. To understand a possible mechanism on how course placement procedures may affect inclusiveness in advanced math courses for ELLs, I draw from theoretical concepts developed by Sørensen (1970), who articulated the dimensions of tracking. In this section, I briefly explain his theory of tracking and its current application, and draw a theoretical framework based on the dimensions of tracking and prior research on

tracking. I conclude the chapter by identifying research gaps that were examined in this study.

Dimensions of Organizational Differentiation

In 1970, Aage Sørensen articulated a conceptual framework to identify the important dimensions of tracking, which he called organizational differentiation. Sørensen developed those concepts when the tracking system in the U.S. was far more rigid than its more recent versions as reviewed earlier. However, his conceptualization has been widely adopted and refined by a number of studies that have sought to understand how tracking differs across schools (Domina et al., 2019; Kelly, 2007) and how tracking affects learning opportunities for students (Karlson, 2015). The core concepts that have been refined over time include inclusiveness, electivity, and selectivity.

Inclusiveness. Inclusiveness referring to the probabilities that students enroll in higher track courses net of their achievement. Sørensen (1970) initially conceptualized inclusiveness as the extent to which opportunities were available, which were measured by proportions of students in the cohort who completed highest secondary level education. Later, scholars utilized his concept of inclusiveness as the probabilities that students can enroll in higher track courses accounting for their prior achievement (Domina et al., 2019; Kelly, 2007).

Electivity and Selectivity. While inclusiveness specified organizational features of tracking based on composition of student in a certain track, electivity and selectivity were described as the contrasting characteristics of assignment procedure (Sørensen, 1970). Electivity referred to the degree to which students are allowed to determine their course

assignment (Sørensen, 1970). In other words, electivity means the extent to which students' choice or preference are allowed to be a determining factor of course placement (Sørensen, 1970). In contrast, selectivity referred to assigning students to different ability grouping based on "some index of learning" (p. 361) which were mainly past and current performance measured by grades or test scores (Sørensen, 1970).

Mechanism of Assignment Procedures Affecting Inclusiveness. Sørensen (1970) articulated possible mechanisms on how selectivity and electivity might affect the student composition in a higher track classroom, especially depending on students' achievement, educational aspiration, and family background. He argued that high electivity might create more homogenous class in terms of students' educational aspiration, while selectivity might produce more homogenous class in respect to their academic achievement. However, Sørensen (1970) also argued that, holding constant the student achievement, electivity might result in producing more homogenous class in terms of family background as students from marginalized background in terms of SES tended to choose lower class whereas their high SES peers tended to choose higher class with the same level of achievement, citing the research conducted in the 1960s. His argument about electivity may run counter to the goal of choice-based approaches, which has been widely adopted as a de-tracking tool over the last three decades. However, research also has shown that educators also have used the choice-based approach with other organizational supports—such as informing students of their options and encouraging struggling students to take more challenging courses—to boost participation of underrepresented students in more rigorous courses. Thus, his argument is worth re-visiting with more recent data and other organizational features that are known to help

increased enrollment of underrepresented students in higher track courses.

The theoretical work of Sørensen (1970) has provided a conceptual framework to research on tracking by explaining the mechanism of how each dimension of tracking functions with characteristics of school or student and affect student achievement (Domina et al., 2019 add). The present study will also draw on his conceptualization and prior research on course-taking to investigate how student choice-based math course placement policy may affect ELLs' math course taking patterns. His concepts of electivity and selectivity informed selection of two distinctively varying course assignment practices: student choice-based approaches and test-based approaches. These two approaches are also contrasting in their purpose; student choice-based approaches aim to create heterogeneous classrooms while test-based approaches intend to create homogenous class in terms of students' perceived abilities. The focus of the present study is student choice criterion as it seeks to identify school features that contribute to creating more heterogenous classrooms in terms of students' academic achievement. I used the probabilities of taking advanced math courses, net of their prior performance, as the indicator of the degree of inclusiveness in schools. Figure 1 shows the conceptual framework drawn from the mechanism of assignment procedure on inclusiveness and the findings from prior research on course taking patterns.

Figure 1. The conceptual framework of student assignment procedures and institutional supports on inclusiveness of the high level math courses based on Sørensen (1970) and prior research on course-taking in high school. The higher position of arrows on the inclusiveness circle represents higher inclusiveness that refers to the probabilities that ELLs enroll in higher track courses net of their academic performance.

Conclusion

Prior research highlighted the unique barriers that ELLs face on their course taking trajectories including deficit-oriented course placement practices, lack of modified pedagogy, cutoff test scores, and little efforts on systemic delivery of information on course placement practices. Those studies provide an in-depth understanding of institutional barriers in multiple domains that ELLs encountered on their course taking trajectories. However, there exist three main research gaps, which the present study addressed.

First, research focused on the relationship between school practices and ELLs' course taking has been mainly qualitative (Harklau, 1994; Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010). In turn, a quantitative study is necessary to examine how the school practices function in ELLs' course taking processes in broader

contexts. Second, prior research did not explicitly examine how student-choice based course placement policies might produce differential results in course allocation for ELLs. Rather, they described that student choice was one of the criteria of course placement policy. As mentioned earlier, student choice is commonly incorporated in high school course placement policy but there is considerable variation to what extent student choice plays a role in determining courses (Kelly, 2007). Thus, there is a need to examine how between-school variation in student-choice based approaches is related to math course distribution for ELLs. Lastly, there is still lack of knowledge on school practices that have a potential to facilitate ELLs' access to higher level courses. Prior research that examined ELLs' course taking trajectories mainly observed constraining school practices. Thus, it is necessary to examine how the facilitating factors reported by studies on historically marginalized students work on ELLs. Especially, considering the choice-based approaches as a widely adopted de-tracking tool with mixed results, investigation on another marginalized group will shed the light on how this strategy works with particular conditions of ELLs.

Therefore, framed by the theoretical work of Sørensen (1970) and prior research, the present study seeks to fill those gaps in the literature of ELLs' course taking patterns by examining student choice-based math course placement policies and institutional supports. Also, I seek to examine if institutional supports such as math encouraging programs and instructional support may be associated with their math trajectories. I utilized a nationally representative sample of high school students in the U.S. to investigate into the questions as described in the following chapter.

Chapter 3: Hypotheses and Method

Given the prior research and theories, the present study seeks to understand how the choice-based math placement policy and institutional supports may affect learning opportunities for ELLs, measured by advanced math courses taken, net of their achievement. I first construct hypotheses on how student choice-based approaches and institutional supports may relate to ELLs' math course taking trajectories and present the research questions. Then, I provide overview on the High School Longitudinal Study of 2009 (HSLs:09) that was utilized to test hypotheses followed by variable selection and analytical strategy.

Research Questions and Hypotheses

The present study drew on prior research on course taking patterns on ELLs and historically marginalized students to make decisions on selecting variables and construct hypotheses. There were three school practices chosen as the focus of the present study: (1) the choice-based math placement policies, (2) school-wide programs encouraging underrepresented students in math, and (3) instructional supports measured by the quality of math professional learning communities. These school practices have been often found as facilitating factors to improve historically marginalized students' access to higher level courses (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). I examined how those practices are associated with the likelihood of advanced math course taking by ELLs, who more likely belong to racially, economically, and linguistically marginalized groups than their non-ELL peers. Thus, research questions for the present study are as follows:

Question 1: How do school practices—student choice-based math placement policies, math encouraging programs for underrepresented students, and instructional

supports measured by math professional learning communities—relate to ELLs’ advanced math course taking, net of their prior achievement as well as other student- and school-characteristics predicting their math course taking patterns?

Question 2: Do math encouraging programs for underrepresented students have any differential effects on the association between student choice-based math placement policies and ELLs’ advanced math course taking?

The hypotheses for Question 1 are as follows; math placement policies that regard students’ choice as an important factor increase ELLs’ likelihood of taking advanced math courses. Emphasis on students’ choice gives ELLs more options for math courses by mitigating academic requirements such as previous courses or grades that ELLs are less likely to meet than their non-ELL peers. Math encouraging programs for underrepresented students and instructional supports also increase ELLs’ likelihood of taking advanced math courses, respectively. When a school has a program to encourage underrepresented students to participate in challenging math courses or make efforts to recruit them into higher level courses, ELLs benefit from such an encouraging program, given that the majority of ELLs are Latinx or students from low-income families. Also, when expecting instructional support in every level of courses, educators who advise ELLs in course placement process or teach them are more willing to place ELLs in higher courses than without such expectation.

The hypothesis for Question 2 is that when student choice-based math placement is implemented along with a math encouraging program for the underrepresented students, they will have a synergetic effect by increasing ELLs’ access to advanced math courses. Systemic efforts to encourage and recruit underrepresented students help ELLs

become aware of their rights and options to choose higher level courses, which result in substantially increased access to advanced math courses.

In the next section, I present the data and the analytical strategy to answer those questions.

Data

The present study utilizes restricted-use data from the High School Longitudinal Study of 2009 (HSLs:09) conducted by the National Center for Education Statistics (NCES). The HSLs: 09 is the most recent national-level longitudinal study, which has followed a nationally representative sample of over 23,000 ninth graders from 944 U.S. high schools since the fall of 2009 (Ingels et al., 2015). As of 2020, the six waves of data collection have been completed following the ninth grader cohort throughout their secondary and postsecondary years: base-year (2009), first follow-up (2012), 2013 update (2013), high school transcripts (2013-2014), second follow-up (2016), and postsecondary transcripts (2017-18) (see Duprey et al., 2020 for detailed information on each wave). Of those datasets, I used the base-year data and high school transcripts data, focusing on math course assignment policy and organizational supports that ninth graders experienced as important predictors at the institutional level for their math course taking trajectories over the course of their high school.

In the base year data collection, the ninth graders took a background survey and math assessment. The surveys were also administered to a principal, a lead counselor, and math teachers who taught the participating students. Those base-year surveys offer specific advantages for the present study as they provide a rich set of variables about students' backgrounds as well as institutional characteristics/practices that can be

exploited for systemic analyzes of students' math course taking patterns across schools. Especially, they contain key information on math course assignment practices, which is rarely available in large data such as state or district level administrative data. Also, math proficiency tests that ninth graders took allow me to control for a critical factor known to be strongly associated with math course-taking patterns. Finally, high school transcript records provide reliable information on students' ELL status and their math course taking during high school.

I restricted the analytic sample to public schools by excluding private and Catholic schools as they may be systematically different from public schools in students' math trajectories. I also exclude public schools without at least one ELL participant in the survey because the present study specifically focuses on ELLs and the gaps between ELLs and non-ELLs in math course taking patterns. Only 200 schools out of 767 public schools that participated in HSLS:09 study had at least one ELL participant. Further, among 200 schools, I again excluded schools that provided no response to questions about their 9th graders' math course placement policy regarding four key items about tests and student choice criteria; 40 schools have missing on all four key items. Thus, the final analytic sample consists of 3,882 students in 140 public high schools with an average of 28 students in each school.

Dependent Variable: The Most Advanced Math Completed

I used the measure of the highest level of math completed (X3THIMATH) to construct an outcome variable which represents whether or not students took advanced math courses in high school. X3THIMATH developed by NCES represents the highest level of math that students completed in high school and categorizes it into one of 14

groups from no math to AP/IB Calculus (Dalton, Ingels, & Fritch, 2015, see Appendix A). The HSLS:09 used the School Codes for the Exchange of Data (SCED) as the basic classification system for secondary school courses (Ingels et al., 2015). The SCED provides a standardized coding system of courses based on the contents covered and ensures comparability of the courses across different states and school districts (Ingels et al., 2015). The highest math course, X3THIMATH, was also created based on SCED code (Ingels et al., 2015).

I used the math pipeline measures developed by Burkam and Lee (2003) to determine whether or not students took advanced courses. Burkam and Lee (2003) analyzed transcript data from the National Educational Longitudinal Study of 1988 and constructed course taking pipelines to capture the relative position of math course categories in the hierarchy of math courses. Specifically, they categorized 47 math courses into eight levels in order of their academic nature from zero to advanced math (Burkam & Lee, 2003). Their math pipeline measure has been widely adopted to gauge math course levels or define advanced/rigorous math courses, by other scholars (e.g., Ashford et al., 2016; Byun et al., 2015; Tyson & Roksa). Following their scheme, I treated trigonometry or beyond as advanced math courses and used dichotomous coding by assigning the numerical value of 1 to represent that a student took at least one advanced math course.

Math Course Placement: Student Choice-based Approaches

I used an item (C1G9MSELECT) about student choice criteria in placing 9th graders in math courses to create a series of indicator variables representing to what extent a school took into account student choice in the math course placement process. A

lead counselor (or person most knowledgeable about the 9th graders) responded to a question stem: “How important is each of the following factors in placing a typical 9th grade student into a mathematics course?” (Ingels et al., 2011) The lead counselor reported the extent to which they agreed about the importance of student and/or parent or guardian selection, using a four-point Likert-type scale; “Not at all important,” “A little important,” “Somewhat important,” and “Very important.” I used the schools where the lead counselor perceived student choice as no important factor as a reference group and created a series of three indicator variables to represent the other responses.

Along with student choice-based policy, I also used three items about test criteria to control for the extent to which a school put the weight on academic achievement. As discussed earlier, test scores may considerably deter ELLs from accessing advanced courses as their academic outcomes are not just far lower than those of their non-ELL peers (Thompson, 2017) but also underrate their understanding of math concepts as their English proficiency is still developing (Abedi & Lord, 2001; Martiniello, 2008; Parker et al., 2009). Thus, it is important to control for a school’s test-based math policy to examine more properly the association between choice-based math placement policy and ELLs’ math course taking. Like the student and/or parent selection item, the lead counselor responded, using a four-point Likert-type scale, about the importance of i) district or state end-of-year or end-of-course exams (C1G9MENDTST), ii) placement tests (C1G9MPLACTST), and iii) standardized tests (C1G9MSTNDTST). I standardized each response and used their average scores to control for the level of a school’s test-based math policy. Table 1 presents the summary of the responses to those two contrasting math placement policies at the school level.

Table 1

School Responses to Importance of Student Choice and Test Results for 9th Grade Math Placement

Math placement criteria	Not at all important	A little important	Somewhat important	Very important	<i>School n</i>	<i>M</i>	<i>SD</i>
District or state end-of-year/course test	19	18	35	65	137	3.07	1.08
Placement tests	27	15	29	63	134	2.96	1.18
Standardized tests	8	12	45	73	138	3.33	0.86
Student/parent choice	10	21	54	53	138	3.09	0.91

Note. Mean and standard deviation were calculated using the original numerical values assigned to each category. Minimum is 1 and maximum 4 in each item.

Institutional Support Programs

Research has identified institutional supports that would create more diverse classrooms in higher level courses (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). Institutional supports include systemic communication about students' right to choose higher track courses, conscious efforts to recruit underrepresented students into higher level courses, awareness of achievement gap, and modify instruction to serve various needs of students of mixed abilities (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). Given the literature, I choose two items as proxies for institutional supports that may be associated with ELLs' math course taking: Encouraging underrepresented students in math (C1PURSUE) and math teacher's perceptions of math professional learning community (X1TMCOMM).

Encouraging Underrepresented Students in Math. A lead counselor responded to a question, "Does your school have any formal programs to encourage underrepresented students to pursue mathematics or science?" This question does not explicitly refer to institutional efforts to recruit underrepresented students for higher level math courses.

However, the existence of such formal programs can be interpreted as an awareness of underrepresentation of minority students in higher level math courses and as conscious efforts to encourage those underrepresented students to participate in more math courses, both of which are known to be critical institutional supports to increase diversity of higher level courses. Encouraging math was coded as a binary variable by NCES in the HSLS:09 base-year dataset.

Math Professional Learning Community. One of the central efforts at the institutional level to diversify the classroom is teachers' conscious efforts to modify instruction or provide instructional supports to help students engage in the classroom regardless of their ability levels (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). I used a scale of math teachers' perceptions of math professional learning community at their school as a proxy for teachers' efforts to identify effective pedagogy or supports to serve students of varying abilities. This scale was created by NCES through principal components factor analysis, using 12 items where math teachers, who taught participating students, responded to a question stem, "To what extent do you agree or disagree with each of the following statements about the math department at your school?" (For detailed information about the scale, see Ingels et al., 2011) 12 items that were used for the scale are as follows:

Math teachers in this department...

- i) share ideas on teaching.
- ii) discuss what was learned at a workshop or conference.
- iii) share and discuss student work.
- iv) discuss particular lessons that were not very successful.

- v) discuss beliefs about teaching and learning.
- vi) share and discuss research on effective teaching methods.
- vii) share and discuss research on effective instructional practices for English language learners.
- viii) explore new teaching approaches for under-performing students.
- ix) make a conscious effort to coordinate the content of courses with other teachers in this school.
- x) are effective at teaching students mathematics.
- xi) provide support to new mathematics teachers.
- xii) are supported and encouraged by the math department's chair or curricular area coordinator.

The factor scores across those 12 items were standardized to a mean of 0 and standard deviation of 1 by NCES (Ingels et al., 2011). I calculated an average score for each school out of those standardized scores and used dichotomous coding for the measure of math professional learning communities by assigning a value of 1 for a school where its average score is higher than the sample average score of 0. Thus, this binary variable represents schools where math teachers rated their math department as having higher-than-average quality of professional learning communities compared to other schools.

Student Backgrounds

Identifying English Language Learners. I used the item, X3ELLSTATUS, to identify ELLs. The Elementary and Secondary Education Act (ESEA) defines ELLs as students whose native language is not English and who receive English language support

programs in elementary or secondary schools. The ELL identification in transcript data from HSLS:09 study is aligned with ESEA's definition. X3ELLSTATUS provides information on students' ELL status based on their transcripts: Whether or not they enrolled in any ELL support program during high school.

Prior Math Achievement. One of the most controversial issues in ability grouping is whether or not prior achievement can fully account for student placement in higher courses (Gamoran, 2010). The technical perspective about ability grouping assumes that students are assigned to different track courses according to their varying academic abilities, which are typically measured by their prior achievement. Empirical research has shown mixed results about the relationship of prior achievement and tracking; some studies found that prior achievement mostly explains enrollment in high track courses (Lucas & Gamoran, 2002; Tach & Farkas, 2006), while other studies showed that prior achievement does not fully account for enrollment in higher track courses (Corra et al. 2011; Muller et al., 2010). The present study also seeks to examine to what extent prior achievement may account for the expected base-line gap between ELLs and non-ELLs in enrollment in advanced math courses. In the base-year data collection, 9th graders took a math assessment in algebraic reasoning along with their background survey. Given that they took the assessment in the fall semester of the 2009-10 school year, their first semester in high school, those math scores can serve as a proxy not just for cognitive skills but also for the effects of prior math course taking. Thus, I used students' mathematics assessment scores (X1TXMTSCOR) as prior achievement, which I expected to be a significant predictor of the subsequent math course taking during high school. The math assessment scores were originally standardized T-scores with a mean of 50 and a

standard deviation of 10, representing each student's position relative to their peers—9th graders as a whole in the fall of 2009—in respect to math achievement (for detail on math assessment contents, see Ingels et al. 2011). I converted the math assessment T-scores into Z-scores with a mean of 0 and a standard deviation of 1 to facilitate the interpretation of association with taking advanced math courses.

Socio-economic Status. Socio-economic status can be another significant predictor of enrollment in higher level math courses. Even net of prior achievement, empirical research has shown the enrollment gap in high track courses between socio-economically marginalized students and their peers (College Board, 2014; Corra et al. 2011; Muller et al., 2010; Riegle-Crumb & Grodsky, 2010). As empirical research has documented, parents from higher socio-economic backgrounds are better informed of schools' course placement policies and the importance of advanced courses, and better positioned to negotiate their children's course taking (Darity et al., 2001; Yonezawa et., 2002). I used the socio-economic status variable (X1SES) that has taken account of parent/guardians' education, occupation, and family income derived from the parent questionnaire (Ingels et al., 2011). This socio-economic index constructed by NCES indicates the relative social and economic status for families containing at least one 9th grader in the U.S. (Ingels et al., 2011).

Ethnicity/Race. Disproportionately high concentration of racially marginalized students in lower track courses has been a challenging issue to resolve as this phenomenon has long been criticized as the mechanism to reinforce social inequality (Gamoran, 2009; Oakes, 2005; Clotfelter et al., 2005; Kalogrides et al., 2013). Sometimes, prior achievement does not fully explain the enrollment gap in higher track

courses between racially marginalized students and their peers (College Board, 2014; Corra et al. 2011; Muller et al., 2010). Research has documented how the course decision process works against racially marginalized students with implicit bias: educators' differential responses to course request or decision based on students' race (Darity et al., 2001; Lewis & Diamond, 2015; Yonezawa et., 2002). In addition, research has found the tendency that racially marginalized students self-select into courses where they feel socially secure, which are often the lower track courses (Darity et al., 2001; Tyson, 2011). Thus, I expect students' race to be one of the predictors that can explain math course placement patterns in high school. I used X1RACE which characterizes students' race/ethnicity to construct five main categories of race/ethnicity: Hispanic, Black, Asian, White, and other. NCES derived race/ethnicity information from the student questionnaire, school rosters, or the parent questionnaire (Ingels et al., 2011). I included four dummy variables indicating Hispanic, Black, Asian, and other race/ethnicity in the model and thereby White serves as a reference group compared to each of those race/ethnicity categories.

Educational Expectations. Research has shown the strong association between taking advanced math courses in high school and enrollment in a four-year college (Byun et al., 2015; Chajewski et al., 2011; Godfrey et al., 2016). The association indicates that high school students who intend to pursue a four-year college degree may be systematically different in their motivation to enroll in challenging math courses from their peers who expect to complete two-year college or less. I use students' expectation for postsecondary education (S1EDUEXPECT) to construct a binary variable for students' educational aspirations for a four-year college and beyond. Students were

asked: “As things stand now, how far in school do you think you will get? I used dichotomous coding for the 11-point categorical answers by assigning a value of 1 for students who answered starting a Bachelor's degree and beyond, and thereby using completion of an Associate's degree and less including a response “I don’t know” as the reference group.

Gender. The final important attribute at student characteristics is students’ gender. The recent scholarship has consistently found that gender disparities in math achievement favoring boys are detected in lower grades but disappear when students reach the middle or high schools (e.g., Cimpian et al., 2016; Lindberg, Hyde, Petersen, & Linn, 2010; Reardon, Fahle, Kalogrides, Podolsky, & Zárate, 2019). In contrast, research has found that female students tend to have a higher probability of enrolling in AP courses than their male peers (e.g., Klopfenstein, 2004a). Considering female students’ tendency to take more challenging courses and similar level of math achievement as their male peer, I expect that there may be possible gender gap in enrollment in advanced math courses. I used X1SEX and created a binary variable by assigning a value of 1 if a student is a female.

School Contexts

I also included school-level covariates that might account for variation in math course taking patterns. These covariate variables include community type, region, student demographic composition, and math faculty credentials. Community type where a school is located may also affect math course taking patterns, especially availability of advanced courses like AP. It is well known that rural schools often experience constrained supply of advanced courses due to limited financial or human resources (Darity et al., 2001;

Klopfenstein, 2004b). Community type (X1LOCALE) characterizes the locale of the school by providing information on whether the school is located in a city, suburb, town, or rural. I combined town and rural areas and used this new category as a reference group in the analysis compared to city and suburb. I also created dummy variables indicating Northeast, Midwest, South, and West out of the categorical variable (X1REGION) and used South as a reference group in the analysis to account for any possible differences among regions. All the data on school type, community type, and region were derived from Common Core of Data 2007-2008 and the Private School Survey 2007-2008 by NCES (Ingels et al., 2011).

I also controlled for student body composition including proportions of students who receive free or reduced price lunch (A1FREELUNCH), who are English language learners (A1ELL), and last year's seniors who went to 4-year, bachelor's degree-granting colleges (A14YRDEGREE). I included those variables in the analysis to capture possible peer effects which are known to explain academic performance net of student characteristics. All the information on the student body came from the school administrator questionnaire, which was mainly completed by the principal (Ingels et al., 2011). I included the student body composition information using Z-scores in the model. Lastly, I used math teaching certification (X1TMCERT) as a proxy for the quality of the math teacher workforce in the school. Teachers who taught students participating in the HSLS:09 study reported their math teaching certification. I consolidated seven categories into three, indicating no certification, temporary/probationary, and regular high school math certification. I assigned a numerical value of 0, 1, 2 for each category respectively to make higher score represent more qualified teachers in terms of certification. I

calculated an average out of those values in each school and included it in the analysis as one of the school-level controls. Table 2 summarizes the descriptive statistics for all student- and school-level variables included in the analysis.

Table 2

Descriptive Statistics of the Variables in the Study (Unweighted)

<i>Variable</i>	<i>Unweighted n</i>	<i>Mean or Proportion</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	<i>Missing</i>
Outcome Variable						
Taking advanced math courses	3451	0.56	0.50			431
Institutional support						
Math PLC	3765	0.56	0.50			117
Encouraging math	3816	0.37	0.48			66
Student background						
ELL status	3462	0.09	0.29			420
Prior math scores	3240	50.94	10.51	24.4	82.19	642
SES	3385	-0.06	0.77	-1.75	2.57	497
Female	3880	0.50	0.50			2
Hispanic	3623	0.23	0.42			259
Black	3623	0.11	0.31			259
Asian	3623	0.15	0.36			259
White	3623	0.41	0.49			259
Other race	3623	0.10	0.30			259
4-year college expectation	3194	0.59	0.49			688
School characteristics						
FRL (%)	3369	40.31	22.46	1	98	513
ELL (%)	3394	9.71	12.72	0	70	488
4-year college attendance (%)	2856	47.88	19.71	5	95	1026
Math teacher certificate	3805	1.82	0.22	0.86	2	77
Urban	3882	0.29	0.45			0
Suburban	3882	0.39	0.49			0
Rural & Town	3882	0.31	0.46			0
Northeast	3882	0.12	0.33			0
Midwest	3882	0.23	0.42			0
South	3882	0.40	0.49			0
West	3882	0.25	0.43			0

Note. Prior math scores (math assessment scores in the fall of the 9th grade), FRL (percentage of students receiving free or reduced-price lunch), ELL (percentage of who are English language learners), and 4-year college attendance (percentage of seniors who went to 4-year college in the previous school year) were converted into z-scores (mean of 0 and standard deviation of 1) when included in the models.

Along with student- and school-level variables, I used the sampling weights for students (W3W1STUTR) created by NCES to account for different selection probabilities and non-responses in base-year and school transcript data (Ingels et al., 2015). The HSLs:09 study used a stratified, two-stage random sample design where schools were selected in the first stage and students were randomly selected from the ninth grade enrollment list from the sampled schools in the second stage (Ingels et al., 2011). The stratified two-stage random sample design creates disproportionate sampling of students or schools resulting in unequal selection probabilities (Ingels et al., 2011). For example, Asians students were over-sampled relative to their proportion in the target population of 9th graders in the U.S. in the 50 United States and the District of Columbia (Ingels et al., 2011). Thus, those students tend to have smaller weights to reflect their proportion in the target population (Ingels et al., 2011). The sampling weight for students was used to ensure that the data represented the target population of the HSLs:09, adjusted for attrition from base-year, 2013 update, and transcript records (Ingels et al., 2015).

Analytic Strategy

Logistic Regression Models

As the outcome is a binary variable, I used a logistic regression to compare the probabilities of taking at least one advanced math course by student choice-based math placement policies and institutional support programs. All analyses used the student-level sampling weights for students to account for the unequal selection probabilities of students and non-response. Also, the stratified two-stage random sample design adopted

by HSLs:09 study typically creates issues of non-independence among observations because of the non-simple random sampling design (Hahs-Vaughn, 2006). For example, students from the same school may have more homogenous characteristics than students who are randomly selected without considering their membership to a school (Hahs-Vaughn, 2006). Thus, complex sampling design including the stratified two-stage random sampling typically violate the assumption of independence, which can lead to underestimate the standard errors due to homogeneity among observations (Hahs-Vaughn, 2006). I used a sandwich estimation procedure to obtain cluster robust standard errors that account for the nested nature of the data (Huang, 2016; Huang, 2018), utilizing the software program, Mplus version 8 (Muthén & Muthén, 2017).

Many observations have missing information on student and school characteristics used for the analyses. To maximize the use of available information, I replaced missing data for all student and school level variables using a multiple imputation method (Graham, 2012). I carried out the multiple imputation by using the Mplus version 8 as it can account for the two-level structure of the HSLs data when imputing missing values (Asparouhov & Muthén, 2010; Muthén & Muthén, 2017). Specifically, using the TYPE=BASIC TWOLEVEL option of the ANALYSIS command, Mplus can impute missing data for the within- and the between-level variables respectively (Asparouhov & Muthén, 2010). It can also handle categorical variables, generating imputed data values that are within the range of each categorical variable (Asparouhov & Muthén, 2010; Muthén & Muthén, 2017). Missing values were predicted using existing values from all the other variables in the analytical sample (Graham, 2012). Following the literature recommending 20 imputations for 10% to 30% missing

information (Allison, 2012; Graham, Olchowski, Gilreath, 2007), I generated 20 imputed datasets, considering the percentages of missing values, which range from 1% to 26% in the sample (see Table 2).

To more systematically examine the association between school practices and advanced math course taking, I conducted a series of logistic regressions. **Model 1** only included ELL status as a predictor to examine the base-line gap between ELLs and non-ELL peers about their likelihood of taking advanced math courses. The equation for Model 1 as follows;

$$\text{logit}(\pi) = \beta_0 + \beta_1 * \text{ELL}_i \quad (1)$$

where β_1 represents the gap of taking advanced math courses between ELLs to non-ELLs. **Model 2** introduced gender and race/ethnicity to see to what extent those student background characteristics would explain the base-line gap observed in Model 1. The equation for Model 2 added those student explanatory variables to equation (1) as follows;

$$\text{logit}(\pi) = \beta_0 + \beta_1 * \text{ELL}_i + \beta_x X_i \quad (2)$$

where X_i represents a vector of dummy variables indicating female (male as a reference group), Hispanic, Black, Asian, and other race (White as a reference group). β_x represents the log of odds ratio between each group and its reference group, respectively, about taking advanced math courses, when controlling for the other variables in the equation.

Model 3 added three predictors to equation (2) to see to what extent students' socio-economic status, college expectations, and prior achievement can explain the observed gaps between ELLs and non-ELLs. The equation for Model 3 is as follows;

$$\text{logit}(\pi) = \beta_0 + \beta_l * \mathbf{ELL}_i + \beta_x X_i + \beta_m M_i \quad (3)$$

where M_i represents a vector of three student-level predictors indicating SES composite, four-year college expectations (community college or less as a reference), and 9th grade math assessment z-scores and β_m represents the estimated contribution of each variable to the log odds of taking advanced math courses.

Model 4 added school practices—student choice-based math policy, math encouraging program, and math professional learning community—along with other school characteristics to equation (3) to see to what extent school characteristics would explain the likelihood of taking advanced math courses. The equation for Model 4 is as follows:

$$\text{logit}(\pi) = \beta_0 + \beta_l * \mathbf{ELL}_i + \beta_x X_i + \beta_m M_i + \beta_s S_j + \beta_w W_j \quad (4)$$

where S_j represents a vector of dummy variables capturing importance of student choice-based math policy—“A little important,” “Somewhat important” and “Very important” using “Not at all important” as a reference—the implementation of math encouraging program for underrepresented students, and the quality of math professional learning community (schools with lower than or at average scored as a reference) and β_s is their main effect. W_j represents a vector of school covariates, representing math test-based policy (an average of three math-based policy items’ z-scores), student body composition in terms of free-reduced lunch receivers, ELLs, and seniors who went to four-year college in the previous school year (each percentage was converted to z-scores with mean of 0 and SD of 1), average score of math teacher credentials, urban and suburban (using combined rural and town as a reference), Northeast, Midwest, and West (South as a reference) and β_w is their corresponding coefficients.

Model 5 introduced two-way interaction terms to answer Research Question 1 about any differential effect of school practices of interests on the association between ELLs and the likelihood of their advanced math course taking. The equation of Model 5 added two-way interaction terms to equation (4) as follows:

$$\text{logit}(\pi) = \beta_0 + \mathbf{ELL}_i * (\beta_l + \beta_q \mathbf{S}_j) + \beta_x \mathbf{X}_i + \beta_m \mathbf{M}_i + \beta_s \mathbf{S}_j + \beta_w \mathbf{W}_j \quad (5)$$

where $\mathbf{ELL}_i * \mathbf{S}_j$ represents a series of two-way interaction terms between ELL status and three levels of student choice-based math placement policies, math encouraging program, and math PLC and β_q is the interaction effect involving these school practices and ELL status, which is the main interest of this study.

Model 6 introduced three-way interaction terms to answer Research Question 2 to see if student choice-based math placement policies have any differential effect on association with ELLs' advanced math course taking, depending on the existence of math encouraging programs for underrepresented students. To include three-way interaction terms in the equation, additional two-way interaction terms also need to be included between student choice-based math policies and math encouraging programs. So, the equation of Model 6 added three-way and two-way interaction terms to equation (5) as such:

$$\mathbf{Enc}_j * (\beta_l \mathbf{Chc1}_j + \beta_{l+1} \mathbf{Chc2}_j + \beta_{l+3} \mathbf{Chc3}_j) + \mathbf{ELL}_i * \mathbf{Enc}_j (\beta_p \mathbf{Chc1}_j + \beta_{p+1} \mathbf{Chc2}_j + \beta_{p+3} \mathbf{Chc3}_j) \quad (6)$$

where $\mathbf{Enc}_j$ represents math encouraging program for underrepresented students, $\mathbf{Chc1-3}$ represents three dummy indicator variables about the importance of student choice in assigning math courses. β_p , β_{p+1} , and β_{p+2} are three-way interaction effects involving ELL status, a series of importance of student choice, and math encouraging

programs, which is another main interest of this study. β_t , β_{t+1} , and β_{t+2} are two-way interaction effects involving a series of importance of student choice, and math encouraging programs.

In sum, this chapter presented the data, the HSLS:09, that this study utilized to explore the possible school practices that may lead to improving ELLs' access to advanced math courses. In particular, this study focused on the three key factors—student choice-based math placement policies, math PLC, and math encouraging programs for underrepresented students—that the prior research has documented as facilitating practices to improve underrepresented students' access to higher level courses. The logistic models were built to see if those school practices may contribute to increasing the likelihood of taking advanced math courses even controlling for prior achievement, educational aspirations, and socio-economic status of the family that are known to influence students' course taking trajectories. In the next chapter, I presented the results of each logistic regression model, starting with descriptive statistics of ELLs.

Chapter 4: Findings

The present study examined if ELLs would benefit from certain school practices—taking into account student choice in assigning math courses, encouraging math for underrepresented students, and math professional learning communities—in regard to the probabilities of taking advanced math courses net of their prior achievement. To more systematically investigate how student- and school-level factors explain students’ course taking, the present study ran a series of logistic regression models that incorporated students’ socio-demographic characteristics and school characteristics in sequence. I found that the quality of math PLCs was positively associated with probabilities of taking advanced math courses when adjusting for ELL status, prior achievement, SES, and educational expectations among others. Subsequently, I introduced two-way and three-way interaction terms to investigate any possible differential effects among ELL course taking and school practices, the main interests of the present study. No interaction terms were statistically significant, indicating no differential effect of any school practices on ELLs. However, the findings supported that ELLs would benefit from high quality math PLCs as much as other students in regard to taking advanced math courses. This section reports the results of analyses using logistic regression models.

Descriptive Statistics

As expected from the prior research, the descriptive data consistently shows the wide-gap of taking advanced math courses between ELLs and their non-ELL peers. In the analytic sample of public schools that had at least one ELL participant in the HSLS:09 study and responded to at least one key criterion about math course placement policies,

the unweighted percentage of students who completed at least one advanced math course (trigonometry or beyond) was 55.8%. 9.5% of students in the analytic sample had participated in ELL support programs/or services in high school. Only 40.1% of ELLs took at least one advanced math course while 57.5% of non-ELL peers took advanced math courses. Also, ELLs were systematically different from non-ELLs in terms of the factors known to strongly predict taking advanced courses: On average, the four-year college expectations, math assessment scores in the 9th grade, and socio-economic status of ELLs were lower than those of non-ELL peers (see Figures 2 and 3).

Figure 2. Percentage of ELLs and non-ELLs in regard to their advanced math course taking and four-year college expectation.

Figure 3. Average scores of ELLs and non-ELLs in regard to their SES composites and 9th grade math assessment z-scores.

Advanced Math Course-Taking Predicted by Student Background Characteristics

Table 3 reports results of a series of logistic regression models where the log odds of taking advanced math courses were predicted by student-level characteristics. In each model, student-level predictors were added sequentially.

Model 1 only included ELL status as a predictor to examine the base-line gap between ELLs and non-ELL peers about their likelihood of taking advanced math courses. The statistically significant coefficient of ELL status ($\beta = -0.56$, $p = 0.021$) in the first column represents the log of odds ratio between ELLs and non-ELLs, meaning that the log odds of taking advanced math courses were 0.56 units lower for ELLs compared to non-ELLs.

The exponentiated regression coefficient [$\exp(-0.56)=0.57$] in the second column represents the odds ratio, indicating that the odds of taking advanced math courses on average decreased by a factor of 0.57 for ELLs compared to non-ELLs. Also the intercept, β_0 in Model 1, represents the log odds of taking advanced math for non-ELLs. When converting the logit to the probability, the predicted probability of taking advanced math courses for non-ELL was 56%² while the predicted probability for ELLs were 42%³ in the final analytic sample when missing values were imputed.

Model 2 added students' gender and race/ethnicity to see to what extent the students' gender and race/ethnicity would explain the base-line gap between ELLs and non-ELLs. Specifically, the log odds of taking advanced math courses were 0.28 units higher for female students compared to male students regardless of ELL status and race/ethnicity. Also, the log odds of being advanced math takers were 1.34 units higher for Asian students compared to White students regardless of their ELL status and gender. In contrast, the log odds of Hispanic or Black students were 0.55 and 0.51 unit lower, respectively, compared to White students regardless of their ELL status and gender. The regression coefficient of ELL status ($\beta = -0.53, p = 0.067$) remains statistically significant at the 10% level, indicating that ELLs are less likely to take advanced math courses in high school compared to non-ELL peers, regardless of their gender or race/ethnicity.

² $\exp(0.24)/(1+\exp(0.24))=0.56$

³ $\exp(0.24-0.56)/(1+\exp(0.24-0.56))=0.42$

Table 3

Probabilities of Taking Advanced Math Predicted by Student Sociodemographic Characteristics

Predictor	Model 1		Model 2		Model 3	
	β	e^{β} (odds ratio)	β	e^{β}	β	e^{β}
Student background						
ELL status	-0.56 (0.24) *	0.57	-0.53 (0.29) ^a	0.59	-0.07 (0.32)	0.93
Female			0.28 (0.11) *	1.32	0.25 (0.14)	1.28
Hispanic			-0.55 (0.18) *	0.58	0.24 (0.30)	1.27
Black			-0.51 (0.18) **	0.60	0.51 (0.26) *	1.66
Asian			1.34 (0.26) ***	3.81	1.08 (0.39) **	2.95
Other race			-0.42 (0.23) ^a	0.66	-0.26 (0.27)	0.77
SES					0.41 (0.11) ***	1.50
4-year college expectation					0.61 (0.14) ***	1.84
Prior math scores					1.09 (0.11) ***	2.99
Intercept	0.24 (0.10) *		0.29 (0.12) *		-0.34 (0.17) *	
-2Log likelihood	5320		5110		4194	
AIC	5324		5125		4215	
BIC	5377		5169		4278	

Note. Standard errors are in parentheses. ^a $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

More specifically, the intercept in Model 2 takes on a different meaning from the intercept in Model 1, representing the log odds of taking advanced courses for non-ELL, white, male students and the predicted probability for such student is 57%⁴. To illustrate a comparison, the predicted probability for taking advanced math course for ELL, white, male is 44%⁵. Also, the results of Model 2 indicate that the likelihood of taking advanced math courses may vary among ELLs when taking into account their gender or race/ethnicity. For example, among ELL male students, the predicted probability of taking advanced math for Asian students was 75%⁶ whereas the predicted probability of Hispanic students was 31%⁷. Figure 4 summaries those results.

Figure 4. Predicted probabilities of taking advanced math among male students before adjusting their SES, four-year college expectations, and 9th grade math assessment scores and school-level characteristics.

⁴ $\exp(0.29)/(1+\exp(0.29))=0.57$

⁵ $\exp(0.29-0.53)/(1+\exp(0.29-0.53))=0.44$

⁶ $\exp(0.29-0.53+1.34)/(1+\exp(0.29-0.53+1.34))=0.75$

⁷ $\exp(0.29-0.53-0.55)/(1+\exp(0.29-0.53-0.55))=0.31$

Model 3 introduced students' socio-economic status (SES), whether or not students expected to finish a four-year college, and 9th grade math assessment scores, all of which are known to be good predictors of taking higher level courses. The coefficient of ELL status is not statistically significant any more in Model 3, indicating that newly added predictors—SES, four-year college expectation, and prior math scores—mostly explain the difference between ELLs and non-ELL peers. Interestingly, the differences observed in Model 2 in the other predictors also turned not statistically significant in Model 3 except Black and Asian. For the Black students, the direction of the coefficient changed as positive, meaning that the odds of taking advanced math courses for Black students increased, on average, by a factor of 1.66 compared to White peers regardless of the other variables in the model. The odds ratio of taking advanced math courses for Asian compared to White peers slightly decreased compared to that of Model 2 but still significant, indicating that Asian students are more likely to take advanced math courses than their White peers even controlling for all the other variables in Model 3.

The results of Model 3 also support the view that student backgrounds other than academic achievement may contribute to the likelihood of taking advanced math courses in high school. As expected from the prior research, prior math achievement, SES, and educational expectation are all positively associated with the likelihood of taking advanced math courses. Specifically, the odds of taking advanced math courses increased by a factor of 2.99 for every unit increase in 9th grade math assessment z-scores, while controlling for all the other variables in Model 3. One unit in math z-scores is one standard deviation and the original 9th grade math score before being converted into z-scores has a standard deviation of 10.51 (see Table 2). So every unit change in z-score is

equivalent to 10.51 score change in original math assessment scores. To illustrate the change in terms of predicted probabilities that increase non-linearly, I took one case when all variables in Model 3 is equal to zero except math, meaning non-ELL White male student from a national average SES family who has no four-year college expectation; The predicted probabilities range from 7% to 86% and every unit change in 9th math z-scores is related from 12% to 26% change in their probabilities (for detail, see Table 4 and Figure 5). The percentage change is large but this result supports in part the technical perspective that math courses are assigned based on students' prior academic performance.

Table 4

Prediction of Taking Advanced Math Based on 9th grade Math Performance with Other Factors Fixed at Zero

Prior math z-score	Log odds	Odds	Factor change in odds	Probability (π)	Additive Change in π
-2	-2.53	0.08		0.07	
-1	-1.43	0.24	2.99	0.19	0.12
0	-0.34	0.71	2.99	0.42	0.22
1	0.76	2.13	2.99	0.68	0.26
2	1.85	6.36	2.99	0.86	0.18

Note. An illustrative case for a non-ELL male student with the national average SES and no four-year college expectations.

Figure 5. Predicted probabilities of taking advanced math among non-ELL male students with the national average SES and no four-year college expectations based on the results of Model 3.

However, SES also contributed to the likelihood of taking advanced math courses; the odds of taking advanced math courses increased by a factor of 1.50 for every increase in SES composite. SES composite shows the family's relative social position in the original sample of HSLS:09 that has a SD of 0.78 with a range of -1.93 to 2.88 (Ingels et al., 2011). Thus, one unit change in SES is quite a large change in terms of family income, parents' educational level, and their occupational status. To illustrate to what extent SES may be associated with the likelihood of taking advanced math courses, again I took one case when all variables in Model 3 are equal to zero except SES, representing non-ELL White male student who has an average math assessment score and has no four-year college expectation; The predicted probabilities range from 24% to 62% and every unit change in SES is related from 8% to 10% change in their probabilities (for detail, see Table 5 and Figure 6). In addition to math achievement and SES, students' expectation to finish a four-year college is also positively associated with the likelihood of taking advanced math courses; the odds of taking advanced math courses on average increased by a factor of 1.84 for students who expected to finish a four-year college to their peers

who expected to finish community college or less even controlling for all other factors in Model 3. The next section reports the results of models that include school practices to examine if they would explain the likelihood of students' math course taking.

Table 5

Prediction of Taking Advanced Math Based on SES with Other Factors Fixed at Zero

Prior math z-score	Log odds	Odds	Factor change in odds	Probability (π)	Additive Change in π
-2	-1.15	0.32		0.24	
-1	-0.75	0.47	1.50	0.32	0.08
0	-0.34	0.71	1.50	0.42	0.09
1	0.07	1.07	1.50	0.52	0.10
2	0.48	1.61	1.50	0.62	0.10

Note. An illustrative case for a non-ELL male student with the average prior math scores and no four-year college expectations.

Figure 6. Predicted probabilities of taking advanced math among non-ELL male student with the average prior math scores and no four-year college expectations based on the results of Model 3.

The Role of School Practices on Students' Advanced Math Course-Taking

Table 6 reported the results of the logistic regression models where the log odds of taking advanced math were predicted by school practices of interests, other school characteristics and student characteristics.

Model 4 added school practices—student choice-based math policy, math encouraging program, and math professional communities—along with other school characteristics. Among all school practices and characteristics, only the quality of math PLC was associated with the likelihood of students' taking advanced math courses. The odds of taking advanced math courses for students who attended a school where math teachers rated their math department's PLC higher than average increased by a factor of 1.78 compared to their peers who attended a school with relatively lower PLC scores when controlling for all the other variables in Model 4. Also, inclusion of school characteristics does not explain the difference observed in student-level predictors; Asian, SES, educational expectation, and academic achievement remained statistically significant while only the coefficient for Black students was not statistically significant.

Model 5 added two-way interaction terms between ELL status and school practices of interest—student choice-based math placement policies, math encouraging program, and quality of math professional learning communities—to answer Research Question 1 about the association between ELLs and those school practices of interest. The results of Model 5 showed that none of interaction terms is statistically significant, meaning that there is no differential effect of those school practices for ELL students (see Table 6).

Table 6

Probabilities of Taking Advanced Math Predicted by Student- and School-level Characteristics

Predictor	Model 4			Model 5			Model 6		
	β		e^{β}	β		e^{β}	β		e^{β}
Student background									
ELL status	-0.02	(0.30)	0.98	-0.24	(1.12)	0.79	1.28	(1.25)	3.59
Female	0.21	(0.14)	1.23	0.20	(0.14)	1.23	0.19	(0.14)	1.21
Hispanic	0.29	(0.22)	1.33	0.29	(0.23)	1.33	0.30	(0.22)	1.35
Black	0.28	(0.25)	1.32	0.28	(0.25)	1.32	0.29	(0.25)	1.33
Asian	1.62	(0.25)***	5.07	1.65	(0.25)***	5.21	1.69	(0.28)***	5.40
Other race	-0.17	(0.22)	0.85	-0.18	(0.22)	0.84	-0.15	(0.21)	0.86
SES	0.47	(0.11)***	1.60	0.46	(0.11)***	1.59	0.46	(0.12)***	1.59
4-year college expectation	0.63	(0.15)***	1.87	0.64	(0.15)***	1.90	0.64	(0.15)***	1.90
Prior math scores	1.21	(0.10)***	3.35	1.22	(0.10)***	3.37	1.23	(0.10)***	3.41
Choice-based math policy									
A little important	0.74	(0.45)	2.09	0.70	(0.50)	2.01	0.22	(0.75)	1.25
Somewhat important	0.51	(0.46)	1.67	0.44	(0.50)	1.56	0.15	(0.72)	1.16
Very important	0.55	(0.43)	1.74	0.54	(0.47)	1.72	0.26	(0.74)	1.29
Test-based math policy	0.15	(0.14)	1.16	0.12	(0.14)	1.13	0.19	(0.17)	1.21
Institutional support									
Math PLC	0.58	(0.25)*	1.78	0.56	(0.26)*	1.74	0.54	(0.25)*	1.72
Encouraging math	0.32	(0.25)	1.38	0.39	(0.28)	1.47	0.04	(1.16)	1.04
School contexts									
% of FRL	0.32	(0.23)	1.38	0.32	(0.23)	1.38	0.32	(0.23)	1.38
% of ELLs	0.03	(0.14)	1.03	0.03	(0.14)	1.03	0.03	(0.14)	1.03
% of 4-year college attendance	0.15	(0.23)	1.16	0.15	(0.23)	1.16	0.18	(0.22)	1.19
Math teacher certificate	-0.39	(0.46)	0.68	-0.36	(0.44)	0.70	-0.29	(0.45)	0.75
Urban	-0.40	(0.33)	0.67	-0.44	(0.33)	0.65	-0.43	(0.33)	0.65

Suburban	-0.02	(0.32)	0.98	-0.03	(0.32)	0.97	-0.07	(0.33)	0.93
Northeast	0.17	(0.35)	1.19	0.18	(0.34)	1.20	0.17	(0.35)	1.90
Midwest	-0.10	(0.32)	0.91	-0.08	(0.32)	0.92	-0.08	(0.32)	0.93
West	-0.54	(0.34)	0.59	-0.51	(0.33)	0.60	-0.43	(0.35)	0.65
Interactions of ELL and school practices									
ELL x Choice (a little)				0.43	(1.08)	1.54	-1.13	(1.36)	0.32
ELL x Choice (somewhat)				0.84	(1.16)	2.32	-0.78	(1.58)	0.46
ELL x Choice (very important)				0.09	(1.17)	1.09	-1.46	(1.40)	0.23
ELL x PLC				-0.02	(0.60)	0.98	0.00	(0.58)	1.00
ELL x Encouraging math (Enc)				-0.61	(0.65)	0.54	-3.28	(2.57)	0.04
Choice (a little) x Enc							0.90	(1.47)	2.47
Choice (somewhat) x Enc							0.28	(1.22)	1.32
Choice (very important) x Enc							0.30	(1.25)	1.34
ELL x Choice (a little) x Enc							2.56	(2.62)	12.94
ELL x Choice (somewhat) x Enc							2.92	(2.79)	18.59
ELL x Choice (very important) x Enc							2.73	(2.75)	15.28
Intercept	-0.24	(1.07)		-0.27	(1.05)		-0.08	(1.12)	
-2Log Likelihood	3936			3922			3902		
AIC	3986			3983			3974		
BIC	4142			4171			4199		

Note. Standard errors are in parentheses. 9th grade math scores, test-based math policy, and proportions of free-reduced lunch students, ELLs, and seniors who attended four-year college are standardized. ^a $p < .10$. $*p < .05$. $**p < .01$. $***p < .001$

Finally, **Model 6** added three-way interaction terms to see if student choice-based math placement policies have any differential effect on association with ELLs' advanced math course taking, depending on the existence of math encouraging programs for underrepresented students. The results of Model 6 showed that none of three-way interaction terms was statistically significant, meaning that there is no differential effect on association with ELLs' advanced math course taking, depending on the existence of math encouraging programs (see Table 6).

This study built each model based on the hypotheses derived from the prior research. However, I also compared the models using three criteria for goodness-of-fit test: i) -2 log likelihood (-2LL), ii) Akaike information criterion (AIC), and iii) Bayesian information criterion (BIC). Lower values of -2LL, AIC, and BIC indicate the better fitting model (Agresti, 2015). -2LL, AIC, and BIC decreased in each step until Model 4, indicating that each set of additional variables improved the model performance. However, when the interaction terms were included in Model 5 and Model 6, -2LL and AIC slightly decreased whereas BIC increased. This divergence is mainly because BIC tends to penalize more severely for complexity of the model (Agresti, 2015). The increased BIC values indicated that inclusion of interaction terms did not improve the model performance. That is also supported by the results of Model 5 and Model 6; specifically, none of the interaction terms explained the association between predictors and students' taking advanced math courses. Comparing overall model fits among Model 1 to Model 6 based on -2LL, AIC, and BIC led to the conclusion that Model 4 provides a better fit for explaining the association between student- and school-level predictors and the odds of taking advanced math courses. Therefore, when discussing the implications of

statistically significant predictors, I primarily used the results of Model 4 unless interaction terms should be explained.

Chapter 5. Discussion

The present study sought to identify school practices that may contribute to ELLs' access to advanced math courses, which are known to have a marked impact on students' educational and professional trajectories (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). I focused on student choice-based placement policy as it has been widely used as a way to create more inclusive classrooms in terms of students' perceived academic abilities. Also, I examined math encouraging programs for underrepresented students and math professional learning communities (PLCs) based on the prior research that documented institutional supports such as modified instruction and recruitment efforts improved enrollment in AP or higher level courses for economically or racially marginalized students (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2013). Among school practices examined, only the PLCs had statistically significant association with the likelihood of taking advanced math courses. The present study controlled for extensive student- and school-level characteristics that may be related to math course taking patterns: students' prior achievement, SES, educational expectations, race/ethnicity, and student body composition among others. The present study found no evidence of differential effects of PLCs on the association between ELLs and the likelihood of taking advanced math courses, meaning that there is neither positive nor negative effect of PLCs depending on ELL status. Thus, the result indicates that ELLs students can also benefit for high quality PLC as other groups of students do. In this section, I discuss findings of the present study and present possible explanations drawing on the literature on tracking and ELLs' course taking patterns. I concluded with policy implications that could support ELLs and boost their access to advanced math courses in

high school.

Student Characteristics Predicting Taking Advanced Math Courses

The present study found that some of student characteristics mostly explained the odds of taking advanced math courses. The variables of prior achievement, SES, educational expectation, and Asian were all positively associated with the odds of taking advanced math courses while controlling for student- and school-level characteristics in the model including ELL status.

One of the most controversial issues in ability grouping is whether or not academic achievement fully explains students' course taking patterns (Gamoran, 2010). Ideally, ability grouping is designed to meet the needs of students at varying academic capacities (Alexander & Cook, 1982; Kelly & Price, 2011). However, the scholarship has been shown that, in practice, the quality of instruction is also stratified by ability grouping (Gamoran, 2004; Kelly & Carbonaro, 2012; Mayer et al., 2018), which in turn contributes to widening achievement gaps between students assigned to high and low tracks over the course of schooling (Penner et al., 2014; Long et al., 2012; Lucas & Gamoran, 2002; Potter & Roksa, 2013). Apart from this instructional quality issue, scholars have found it concerning that racially or socio-economically marginalized students are less likely to access to higher level courses even with comparable academic achievement (College Board, 2014; Corra et al. 2011; Lucas & Berends, 2002; Muller et al., 2010).

Not surprisingly, the present study also found that prior achievement was a strong predictor of taking advanced math courses. For every one standard deviation increase in math z-scores, the odds of taking advanced math courses increased by a factor of 3.35

regardless of student- and school-level characteristics.

However, the findings of the present study also demonstrated that prior achievement does not fully account for the probability of taking advanced math courses. Family's SES also matters. For every unit increase in SES composite, the odds of taking advanced math courses increased by a factor of 1.60 when controlling for student- and school-level characteristics including prior math achievement. Another issue in ability grouping is a racial difference of participating in higher level courses. However, the findings of the present study provide no evidence to support racial/ethnic differences. The observed baseline differences among racial/ethnic groups were mostly gone once prior achievement, SES, and educational expectations were taken into account. One exception was Asian students who consistently showed a positive association with the odds of taking advanced math courses compared to white students even controlling for all other factors in the full model. Also, as prior research has shown (Darity et al., 2001; Yonezawa et., 2002), students' expectation to finish four-year college was also predictive of taking advanced math courses; the odds of taking advanced math courses for students with four-year college expectation is 1.87 times odds compared to their counterparts (community college or less) when controlling for all other factors including SES and prior achievement.

ELL status and Taking Advanced Math Courses

The findings of the present study did not support the difference between ELLs and non-ELLs about the likelihood of taking advanced math courses; the baseline gap observed between ELLs and non-ELLs was mostly explained by prior achievement, SES, and educational expectations. However, findings also highlighted the vulnerable position

of ELLs in course-taking trajectories. First, ELLs' academic performance tends to be, on average, far lower than that of non-ELL peers (Kanno & Kangas, 2014; Thompson, 2017; Xiong, 2010). Furthermore, as empirical research has shown, test outcomes administered in English may underrate their academic abilities (Abedi & Lord, 2001; Martiniello, 2008; Parker et al., 2009). Second, ELLs are more likely to belong to low-income families than their non-ELL peers. According to the American Community Survey (2008-2012), ELLs are 1.81 times more likely to be eligible for the free-reduced lunch program than non-ELL peers (NAS, 2017). Lastly, the prior research on ELLs' course taking trajectories consistently documented the cases where ELLs internalized the deficit orientation and lowered their educational aspirations during their schooling (Gándara & Orfield, 2012; Kanno, 2018; Kanno & Kangas, 2014). The findings indicate that on average the relatively lower positions of ELLs on positive factors—academic performance, SES, and college expectations—should be considered along with their ELL status in course assigning processes.

Student Choice and Math Encouraging Program for Underrepresented Students

Student choice-based math placement policies. Increasing students' latitude in course decision making processes has been widely adopted as a de-tracking strategy to improve historically marginalized students' access to higher level courses (Bavis, 2016; Kelly, 2007; Rubin, 2006). The idea is that more students would take higher level courses if more course options had reduced academic requirements (Rubin, 2006; Yonezawa et al., 2002). The findings of the present study provide no evidence to support the hypothesis that stronger emphasis on student choice would lead to higher probabilities of taking advanced math courses in high school. There was no difference between schools

taking no account of student choice and schools considering student choice as an important factor at a varying level (a little, somewhat, very important) when accounting for all other factors including prior achievement, SES, and race/ethnicity. The present study found no differential effect of student choice-based math policy on ELLs' access to advanced math courses, either. The findings are in line with prior research that found that AP's open access policy had no improvement on marginalized students' access to AP courses once academic achievement was taken into account, indicating that access to AP courses are mainly determined by prior achievement even in the existence of open access policy (Corra et al., 2011; Rodriguez & McGuire, 2019).

The prior research may provide the possible explanations about no statistically significant difference of student choice on students' access to advanced math courses. Even in schools that consider student choice as an important factor, students may have limited course options due to prerequisites such as previous courses or screening tests (Kelly, 2007; Kolluri, 2019; Yonezawa et al., 2002). Schools may allow students to choose courses but they should be first academically eligible to take a certain course (Kelly, 2007; Yonezawa et al., 2002). In such cases, prerequisites can restrict students' rights to choose considerably, leaving little room to make difference in students' access to higher level courses.

Prior research also pointed out that the implementation of student choice based placement policy may not be sufficient conditions to improve marginalized students' access to higher level courses (Darity et al., 2001; Lewis & Diamond, 2015; Yonezawa et al., 2002). Minority or lower SES students and parents may not be aware of such course placement process without a systemic effort to disseminate their rights to request a

different course (Darity et al., 2001; Lewis & Diamond, 2015; Yonezawa et al., 2002).

On top of uneven information distribution, ELLs and their families have been often found to lack some understanding about the importance of advanced courses for postsecondary options (Guo, 2006, Kanno & Kangas, 2014; Xiong, 2010). Additionally, language barrier and unfamiliarity with U.S. school practices further restrain them from exercising their rights to request a higher level course (Guo, 2006, Kanno & Kangas, 2014; Xiong, 2010).

Encouraging underrepresented students in math. Along with student choice-based math placement policy, the present study also examined the possibility that math encouraging programs for underrepresented students would lead to increased access to advanced math courses, especially implemented with choice-based math placement policies. Research has documented systemic communication about enrollment policies and conscious efforts to recruit underrepresented or academically struggling students into higher level courses as one of working strategies to improve inclusiveness in high level courses (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). The present study assumed that math encouraging programs for underrepresented students represent the aforementioned efforts to actively promote open access policy and recruit underrepresented students for higher level math courses. Also, the present study posited that, when a school has a program to encourage underrepresented students to participate in more math courses, ELLs benefit from such an encouraging program, given that the majority of ELLs are Latinx or students from low-income families. The findings of the present study provide no evidence that math encouraging programs for underrepresented students can influence the probability of taking advanced math courses, net of their prior

achievement and other student- and school-level factors. No differential effect of math encouraging programs was found on ELLs or/and implemented with student choice-based math placement policies, either. However, this finding should be interpreted with caution as math encouraging programs did not directly measure how well underrepresented students were informed of their school's student choice based policy. If there was a measure capturing the level of information that parents and students had about their school's math placement policy, the present study could have more explicitly investigated the differential effects involving level of information, student choice-based math placement policy, and ELLs.

Professional Learning Communities Predictive of Taking Advanced Math Courses

Another school practice examined by the present study was math professional learning communities (PLCs). Research has shown that one of the critical institutional supports to improve marginalized students' access to higher level courses is teachers' conscious efforts to modify instruction or provide instructional supports to help students engaged in classroom regardless of their ability levels (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). The technical challenge of teaching mixed-ability classes has been known as a major barrier to creating more inclusive classrooms (Gamoran, 2009; Loveless, 1999; Rubin, 2006). Ability grouping is so embedded in high school curriculum that few teachers are equipped to teach students of varying abilities or needs in one classroom (Gamoran, 2009). So, teachers in high school often resist mixed ability classrooms, citing instructional difficulties (Gamoran, 2009; Loveless, 1999; Rubin, 2006). Lack of differentiated instruction in high level courses was also one of the main reasons that educators eschewed placing ELLs in such challenging courses (Kanno &

Kangas, 2014).

To measure to what extent math teachers were prepared to serve students of varying abilities or needs, I used one of the teacher scales created by NCES: math teachers' perception of their school's professional learning communities. This scale was created through principal components factor analysis, using 12 items that math teachers rated about the math department at their schools (Ingels et al., 2011). Items used to create PLC scale in HSL:09 was about sharing the expertise and ideas to collaboratively improve teaching and learning; they also included "sharing and discussing research on effective instructional practices for ELLs" and "exploring new teaching approaches for under-performing students." The findings of the present study indicate that high quality PLCs may help improve students' access to advanced math courses, net of their prior achievement among other controls. The odds of taking advanced math courses for students who attended a school with higher-than-average quality of math PLCs increased by a factor of 1.78 compared to their peers who attended a school with relatively lower PLCs, when controlling for student- and school-level characteristics. However, the present study found no differential effect of math PLC on ELLs' access to advanced math course taking; ELLs benefited from high quality of math PLC as much as other groups of students.

Implications for Leadership and Teachers

The findings of the present study suggest the possibilities that institutional efforts, especially focused on instruction, may impact on students' course taking trajectories that are heavily influenced by students' prior academic achievement and background. The present study examined three school practices that correspond to working strategies that

prior studies have documented in schools that improved marginalized students' access to higher level courses: student choice-based math placement policies, math encouraging programs for underrepresented students, and math professional learning communities. Among those practices, the present study found that only math PLC matters. The present study controlled for extensive sets of student- and school-level characteristics including students' prior achievement, race/ethnicity, SES, educational aspiration—the factors known to influence students' course taking trajectories (e.g., Darity et al., 2001; Gamoran, 2009; Klopfenstein, 2004a; Oakes, 2005). Thus, even though the present study is not able to identify a causal effect of math PLC by design, the finding still indicates that schools with high quality math PLC make a positive difference on students' access to advanced math courses. The finding is especially meaningful because the study is about math. As prior studies have suggested, students' academic achievement in the eighth grade or prior to high school strongly predict the highest math that student can take at the end of high school (Gamoran & Hannigan, 2000; Kelly, 2007; Stevenson et al., 1994). Even controlling for prior achievement of students among other controls, high quality math PLC shows the possibility to boost students' access to advanced math courses at the end of their high school year, net of the incoming math levels.

The findings also indicate that schools endeavoring to create more inclusive classrooms in terms of academic abilities should help teachers forge collaborative working environments where they can learn from each other about effective teaching for students of varying abilities and needs. As prior research has documented, teachers' resistance to mixed-ability classrooms mainly stems from their concern about instructional difficulties to teach students of varying academic abilities in a classroom

(Gamoran, 2009; Loveless, 1999; Rubin, 2006). School leadership should be aware of such pedagogical concerns and attentive to providing supports to help create PLCs in their schools, which especially focus on serving students of varying academic levels as well as those who are still developing their English proficiency. As research on PLCs suggests, leadership plays an important role as leaders create conditions fostering PLCs by creating a learning culture, assigning resources, making time, and providing professional development opportunities (see review by Stoll et al., 2006).

The present study did not explicitly examine types of instructional supports that may work, but rather investigated a collaboration level among math teachers to learn effective teaching methods and discuss their teaching/learning beliefs, including ELLs or underperforming students. However, prior studies that documented schools with markedly improved access to higher level courses may provide some examples about instructional supports that lead to creating more inclusive classrooms. First, teachers may more willingly encourage underperforming students to enroll in higher level courses when classroom instruction is oriented toward engaging students of different academic levels. Kolluri (2018) documented that teachers utilized class discussion, group projects, and group essay writings to boost collaborative learning experience and thereby avoid isolating underperforming students. Second, building community of learning among students is also important to engage students of varying academic levels or racially underrepresented students (Kolluri, 2018; Pamela, 2014). Pamela (2014) documented collaboration of counselors and AP teachers to recruit underrepresented Black students to an AP course. Interventions focused on not just building trust between teachers and Black students with academic potential but also forming peer relationships among Black

students to cultivate a community of learning. Lastly, building a culture of high expectations is also a key to successfully teaching mixed ability classrooms (LaPrade, 2011). With high expectations, teachers maintain the accelerated curriculum while providing emotional supports to struggling students by, for example, using supportive words, encouraging to ask questions for clarification, and maximizing learning time (Mayer et al., 2018; LaPrade, 2011).

The finding of the study did not support the differential effect of math PLC on ELLs' taking advanced math courses. Regardless of ELL status, students may benefit from a high quality math PLC in their school. However, this finding also suggests that training content area teachers may contribute to creating more inclusive classrooms for ELLs net of their academic achievement. In this sense, the recent pedagogical endeavor in math education will inform leaders and teachers of why and how to engage ELLs in challenging math courses at the same pace as non-ELL peers (de Araujo et al., 2018; Song & Coppersmith, 2020). The recent perspective on language learning highlights participation in rigorous academic courses is an essential key to developing English proficiency (Haynes & Zacarian, 2010; Lee, Quinn, Valdés, 2013; Moschkovich, 2015). Embracing this idea of integrating language and content, researchers have developed classroom instructions and professional learning that stress on visual representation (e.g., Crawford, 2013; Freeman, 2012; Warren, & Miller, 2015) or capitalizing on their first languages (e.g., Dominguez, 2011; Rubinstein-Ávila et al., 2015) to make challenging math courses accessible to ELLs. Also, the findings of prior studies suggest that non-ELL peers also benefit from modified instructions initially designed to help ELLs (Warren, & Miller, 2015).

Limitations of the Study and Directions of Future Study

The present study has some limitations that should be considered when interpreting the findings. More research is needed to address these limitations and develop policies about ELLs' course taking in high school. First, the present study did not distinguish when students exited ELL programs during high school. The present study utilized ELL status that HSLS:09 study extracted from students' transcript data: whether or not students had ever enrolled in any ELL support program during high school. Students who moved out of ELL status very early in high school, for example, in the ninth grade, might be systematically different from students who stayed in ELL programs until the end of high school. However, the present study treated all of them as one homogenous group of ELLs. Furthermore, prior research has shown that ELL service programs may have unintended negative impacts on course taking trajectories in high school, e.g., pushing out core contents courses (Callahan et al., 2010; Dabach & Callahan, 2011; Gándara et al., 2003). In this sense, the timing of exit in high school or how long students had maintained ELL status before high school might be another important factor but the present study was unable to consider it due to data limitation. A future study with the exit timing information will provide additional insights on ELL status and its impact on advanced math course taking.

Second, the present study did not take into account the types of ELL programs that ELLs participated in, for example, dual-language program, pull-out, or sheltered program. Prior studies suggest that the types of ELL programs influence academic outcomes such as math and reading test scores (e.g., Steele, 2017; Umansky & Reardon, 2014; Valentino & Reardon, 2015). Especially, among ELL program choices, dual

language programs that include native English speakers as well as ELLs in the same classroom have been found to produce positive academic outcomes (Steele, 2017; Umansky & Reardon, 2014; Valentino & Reardon, 2015). Thus, future research that includes ELL programs in the analysis will produce more detailed information about participation in different ELL programs and their influence on each participant's taking advanced math courses.

Third, the present study posits that math encouraging program for underrepresented student represents systemic communication about math enrollment policies and conscious efforts to recruit underrepresented students into higher level courses that prior studies observed in schools with improved access for marginalized students (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). The present study was particularly interested in any differential effect of math encouraging program about ELLs' taking advanced math courses. The math encouraging program, however, did not explicitly measure how well informed students and parents about math course placement policy. Especially, ELLs and their parents tend to be poorly informed about placement information due to language barriers, unfamiliarity with U.S. school practices, or implication of taking advanced courses on postsecondary options (Guo, 2006, Kanno & Kangas, 2014; Xiong, 2010). Thus, explicit measure that captured level of information that ELLs and their parents had about the course options would more clearly uncover the relationships among ELLs, level of course placement information, and importance of student choice in their math course decision process.

Lastly, the results of the present study represent the association among variables and should not be interpreted as a causal effect. The key finding of the present study is

that high quality math PLC is positively associated with the probability of taking advanced math courses. It attempted to reduce selection bias by controlling for a comprehensive set of student- and school-level characteristics including prior achievement, educational aspiration, and SES that are known to substantially influence students' course taking trajectories. However, students who enrolled in high math PLC schools might still be systematically different from their peers who enrolled in relatively lower math PLC schools on unobserved characteristics. Thus, although the finding of the present study suggests the possible role of math PLC on boosting access to advanced math courses net of prior achievement, research designed to identify a causal effect could draw more definite conclusions about the effect of math PLC on advanced math course taking.

Conclusion

Over the last three decades in the U.S., schools have endeavored to provide more equitable access to rigorous courses, especially for racially or socioeconomically marginalized students, and increased those students' participation in higher level courses such as AP (Judson & Hobson, 2015; Kettler & Hurst, 2017; Rodriguez & McGuire, 2019). Despite such improvement, the gaps in high level courses enrollment among racially or socioeconomically different student groups still remain with those marginalized students still underrepresented in the high level courses (Domina & Saldana, 2012; Kettler & Hurst, 2017; Rodriguez & McGuire, 2019).

The present study focused on another marginalized group of students, ELLs. ELLs face a triple disadvantage of limited English proficiency, race, and poverty (Gamoran, 2009). Furthermore, ELLs are not just overrepresented in lower track courses

(Callahan et al., 2010; Estrada, 2014; Hanson et al., 2016; Umansky, 2016a) but take fewer core academic content areas like math and science than their non-ELL peers (Callahan & Shifrer, 2016; Estrada, 2014; Gándara et al., 2003; Hanson et al., 2016; Umansky, 2016a). Prior research has documented problematic practices and course structures limiting ELLs' access to higher level courses (Callahan, 2017; Gándara & Hopkins, 2010; Kanno, 2018; Kanno & Kangas, 2014; Thompson, 2017; Zuniga et al., 2005). However, few studies attempted to explicitly identify school practices that may improve ELLs' access to high level courses which often correspond to rigorous courses.

Thus, the present study focused on three key school practices in association with ELLs' taking advanced math: student choice-based math placement policies, math encouraging programs for underrepresented students, and math professional learning communities (PLC), which prior research have documented as facilitating factors to improve historically marginalized students' access to higher level courses (Kolluri, 2019; LaPrade, 2011; Pamela et al., 2014). Also, it used whether or not a student took advanced math courses (trigonometry or beyond) as an outcome because taking advanced math have significant implication on students' educational and professional trajectories (e.g. Byun et al., 2015; Godfrey et al., 2016; Rose & Betts, 2004). Furthermore, as National Academies of Sciences, Engineering, and Medicine (NAS, 2018) stressed, taking advanced math in high school is a particularly critical issue for ELLs in regard to their participation in the STEM workforce in the future.

The present study found that only math PLCs had a statistically significant association with the probability of taking advanced math courses, net of prior achievement and other student- and school-level factors. The math PLCs examined here

represented a collaboration among math teachers to learn effective teaching methods and discuss their teaching/learning belief for students including ELLs or under-performing students. The main focus of the present study was if school practices improved ELLs' access to advanced math courses. The present study found no differential effects of school practices and ELLs' taking advanced math courses. However, the findings indicate that ELLs can also benefit from high quality math PLCs as much as other students.

The key finding of the present study suggests the possible area that school leadership and educators should develop to improve students' access to advanced math courses net of their prior achievement. This finding is particularly important because math achievement prior to high school strongly predicts math course taking trajectories in high school due to the sequential nature of math course structure (Kelly, 2007; Stevenson et al., 1994). Even adjusting for prior achievement and other factors including SES and educational expectations, math PLCs provide the possibility that school can make a difference even in math, the subject that structurally allows little mobility across course levels or topics net of their prior performance. The role of school leadership is as important as teachers in building PLCs; leadership can create conditions for PLCs as they cultivate a learning culture, allocate resources and time, and decide on professional development, all of which are critical for teachers to continuously develop their professional knowledge and collaborate with colleagues (see review by Stoll et al., 2006).

The key finding of the present study supports the potential benefit that prior studies documented to instructionally support mixed-ability classes; i) designing class instruction oriented toward engaging students of varying academic levels utilizing class

discussion, group projected, and group essay writings to boost collaborative learning experience, ii) building trust between teachers and students as well as among students, especially for underrepresented students, and iii) maintaining high expectations for the whole class while providing emotional supports and encouragement (Kolluri, 2018; LaPrade, 2011; Pamela, 2014).

Particularly for ELLs, the finding suggests that training content area teachers may help ELLs more readily access academically challenging courses net of their academic performance. The recent scholarship on language learning proposes that it is imperative to engage ELLs in rigorous academic courses at the same pace as non-ELL peers as learning language and academic contents are neither separate nor sequential process (Haynes & Zacarian, 2010; Lee et al., 2013; Moschkovich, 2015). In math education, researchers have developed pedagogical approaches and professional learning that place more emphasis on visual representation and utilize students' first languages among others to boost ELLs' engagement in math courses (e.g. Crawford, 2013; Rubinstein-Ávila et al., 2015; Warren, & Miller, 2015). Promisingly, research has found that teaching methods primarily designed to help ELLs also show positive outcomes for non-ELLs (Warren, & Miller, 2015).

In conclusion, the present study contributes to the literature on ELLs' course taking in high school by highlighting the possible positive impact that math PLCs may have on advanced math course taking trajectories. Future studies with more detailed information about ELLs and types of ELL programs would further build our understanding of the nuanced relationships between school practices and ELLs' course taking trajectories. Most importantly, there should be more research that explicitly

investigates school policies and practices that may facilitate ELLs' access to higher level courses in high school.

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Appendix A

The Highest Level Math Course Taken/Pipeline

Original categories from HSL:09 (X3THIMATH)	Math pipeline measure by Burkam and Lee (2003)	
	Academic level	Course name
No Math	No math	
Basic math	Non-Academic	General; Basic; Consumer;
Other math		Technical; Vocational; Review
Pre-algebra	Low Academic	Pre-Algebra
		Algebra 1 (Part 1 or 2)
		Geometry, Informal
Algebra I	Middle Academic	Algebra 1
Geometry		Geometry, Plane
		Geometry, Plane & Solid
		Unified 1 or 2
Algebra II	Middle Academic II	Algebra 2; Unified 3
Trigonometry	Advanced I	Algebra 3; Linear Algebra
Other advanced math		Trigonometry
Probability and statistics		Probability
Other AP/IB math		Statistics
Pre-calculus	Advanced II	Pre-Calculus
		Intro Analysis
Calculus	Advanced III	AP Calculus
AP/IB Calculus		Calculus

Note. Trigonometry and beyond in the HSL:09 original item were categorized as advanced math courses in this study following the math pipeline measure (Advanced I to III) developed by Burkan and Lee (2003).

VITA

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