The Social Dynamics of Mathematics Coursetaking in High School[1]

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This study examines how high school boys' and girls' academic effort, in the form of math coursetaking, is influenced by members of their social contexts. The authors argue that adolescents' social contexts are defined, in part, by clusters of students (termed "local positions") who take courses that differentiate them from others. Using course transcript data from the recent Adolescent Health and Academic Achievement Study, the authors employ a new network algorithm to identify local positions in 78 high schools in the National Longitudinal Study of Adolescent Health. Incorporating the local positions into multilevel models of math coursetaking, the authors find that girls are highly responsive to the social norms in their local positions, which contributes to homogeneity within and heterogeneity between local positions.

> "The adolescent is choosing how to invest time, and . . . the choices depend greatly on the social system surrounding them" (Coleman 1996, p. 346).

This study examines how high school boys' and girls' academic effort, in the form of mathematics coursetaking, is influenced by their social contexts. The literature on sociology of education has established how ado-

lescent coursetaking is influenced by schools' decisions and resource allocations (e.g., Natriello, Pallas, and Alexander 1989; Hallinan 1991; Useem 1992). Other sociologists have described education, independent of the school's function as a social institution, in terms of status attainment, arguing that adolescents and young adults are influenced by their parents' education, occupations, and aspirations (Sewell and Hauser 1976; Steelman and Powell 1991). Complementing status attainment theory, standard economic models directly address parents' motivations for investing in their children for long-term human capital benefits (Adelman 1999). But, as implied by Coleman's quote in the epigraph above, while adolescents may be influenced by adults, including school faculty, administrators, and parents, they may also respond to their peers in making short- and long-term educational decisions (see also Sizer 1984; Crosnoe, Cavanagh, and Elder 2003; Riegle-Crumb, Farkas, and Muller 2006). In this article we examine how an adolescent may be influenced in particular by the cluster of students with whom she takes courses—which we term the local position.

We focus specifically on effort in the domain of math coursetaking for four reasons. First, math has gained increasing attention in the popular press (e.g., Zhao 2005; Wolf 2006; Klein 2007; see also the review by Schoenfeld 2004) and in scholarly outlets (e.g., CPGE 2006; Simpkins, Davis-Kean, and Eccles 2006) for its potential contributions to society. Second, math is an important gateway to other advanced courses and college entry and therefore to pursuing human capital (Sells 1973; Adelman 1999; Simpkins et al. 2006; Sadler and Tai 2007). Third, math has long been a key to the social organization of the school, as it is used to delineate academic tracks (Stevenson, Schiller, and Schneider 1994; Gamoran and Hannigan 2000; Lucas and Good 2001). Fourth, although math coursetaking has been the focus of considerable empirical study, here we are able to measure it with highly reliable transcript data. These data are from the new Adolescent Health and Academic Achievement (AHAA) study, an addition to the rich, nationally representative data of Add Health, an ongoing representative study of American students in grades

7 –12 in 1994 (see Bearman, Jones, and Udry 1997). Using these data, we address our primary empirical research question: How do high school students' social contexts influence their decisions to advance in math courses?

Our focus on social contexts and on math as an example of academic effort calls for a careful delineation by gender. Historically, girls and boys have differed substantially in their math coursetaking (Fennema and Sherman 1977; Armstrong 1981; Elmore and Vasu 1986; Oakes 1990; Hyde and Kling 2001). One argument is that these differences may be a function of motivation. As argued by Parsons, Adler, and Meece (1984) and by Eccles (1994), boys may continue to perceive themselves as more competent in math and to have a stronger interest in math than girls, independent of ability (Correll 2001). Put differently, math is perceived as part of a masculine domain, and as a result boys perceive themselves to have a better fit with math than girls do (Fennema and Sherman 1977; Fennema and Sherman 1978; Armstrong 1981; Meece et al. 1982; Whyte 1986; Hyde et al. 1990; Correll 2001, p. 1696; Simpkins et al. 2006). Furthermore, it may be that expectations and value are relative: boys may value math more because they are relatively weaker than girls in language and social skills (National Center for Education Statistics 2000).

It is critical to state, however, that this study is not about differences in relative levels of mathematics proficiency and attainment, as many of those differences have dissipated recently (Xie and Shauman 2003; Riegle-Crumb et al. 2006; Shettle et al. 2007). Instead, our focus is on how adolescents respond to their social contexts and how those responses may depend on gender. Our focus on social contexts makes gender all the more salient; Akerlof and Kranton refer to gender as the "most prominent division of social category" (2002, p. 1177) because it is generally easily observed and is core to adolescent (and adult) identities. Differences between boys and girls in their responses to social contexts can then give insight into the efficacy of policies intended to elicit more academic effort (e.g., high-stakes testing or graduation requirements) as well as the unintended consequences of policies and practices that involve the social organization of the school (e.g., Catsambis, Mulkey, and Crain 1999; Moody 2001*b*).

DEFINING SOCIAL CONTEXTS

To evaluate the effects of social contexts on adolescent motivation, one must define and identify the most salient social contexts in adolescents' lives. On the one hand is the school itself, which is, in its essence, a large collection of students in varying degrees of familiarity; on the other hand

are friendships, the close personal relationships less immediate than the family. Yet the extensive variation in coursetaking and academic outcomes within schools (Frank 1998; Harter and Fischer 1999; Raudenbush and Bryk 2002) and the recent findings that friendships often come with a level of acceptance that actually weakens their power to change adolescent behavior (Brown and Klute 2003) suggest that the most salient social contexts for adolescents are not defined exclusively by schools or close friends, the former being too remote and the latter too intimate. Instead, the most salient context lies in between these two levels: the network of peers with whom adolescents identify and with whom they *would like to be* friends (Harter and Fischer 1999; Call and Mortimer 2001; Haynie 2001; Giordano 2003; Crosnoe et al. 2008).

Although suggested by theory and occasionally described by ethnography (Cooley [1902] 1983), this intermediate social context—a network narrower than the school but wider than personal relationships—has proven difficult to identify systematically across schools. Certainly, research in some disciplines has made some progress. For one example, sociologists of education have examined the wider network defined by the organization of coursetaking into academic tracks (e.g., Hallinan and Sorensen 1985). In addition, both economists (Akerlof and Kranton 2002) and developmental psychologists (Barber, Eccles, and Stone 2001) have explored the concept of social categories—jocks, nerds, members of the leading crowd, etc.—in the high school.

Although academic tracks and social categories have deep histories as characterizations of the social organization of schools (Sorenson 1970), neither is a completely satisfactory representation of adolescent social contexts in contemporary high schools. Traditional tracking systems have ebbed (see, e.g., Oakes, Wells, and Jones 1997), so a new conceptualization must recognize the tendency for contemporary students to take courses at different levels across subject areas. On the other hand, the perceptual nature of social categories must be theoretically and empirically linked to social interaction to be more sociologically salient.

Thus, working from a conceptual foundation created by both tracking and social categories, we describe the social organization of schools in terms of sets of students within a school who participate in uniquely identifying sets of courses (Powell, Farrar, and Cohen 1985). We refer to a set of students as members of a local position. But, critically, a local position is more than just a set of adolescents, because it is also defined by the focal (Feld 1981) courses taken by its members. In other words, a local position is a group of adolescents who, by virtue of their course-taking, share a social and academic space in school.

Our attention to the effects of social contexts compels us to return to gender, in particular to the differences between boys' and girls' responses

to their social contexts. Research finds that females are more in tune with, and reactive to, their social surroundings and the people within them, largely as a consequence of gender socialization beginning in early childhood (Gilligan 1982). Furthermore, as girls grow older they attach greater importance to their social relationships. This is perhaps most pronounced during adolescence, when girls turn to those around them for encouragement and validation as they forge their adult identities and sense of self (Gilligan 1982; Eccles, Adler, and Meece 1984). Additionally, more recent literature has argued that the salience of gender may be greater in some social interactions or contexts than in others (Chafetz 1997; Ridgeway and Smith-Lovin 1999; Ridgeway and Correll 2004). A domain associated with masculinity, such as a math course, is a key context in which gender is likely to be a salient factor (Correll 2001) and in which girls might look to their same-gender peers for cues about behavior.

Thus, while both boys and girls respond to social influences and pressures during high school, girls' social relationships and interactions have been shown to have more pronounced implications for their academic choices, particularly in certain areas (Beutel and Marini 1995; Leslie, McClure, and Oaxaca 1998; Riegle-Crumb et al. 2006). Yet prior research on this issue has been limited to the exploration of the influence of friends, as in a recent study by Riegle-Crumb et al. (2006) that focused on the effects of friends on girls' and boys' advanced coursetaking decisions in high school. Our study is unique in that it considers the other students who comprise the social context of schooling. Is it the case that girls' math coursetaking is more responsive than boys' to all social contexts (e.g., friends, potential friends, schoolmates), or do the differential responses vary by context? This is an important facet of our empirical study.

THEORETICAL BACKGROUND

Peer Influence in Adolescence

The foundation for this research is, of course, the concept that peers influence each other. Across disciplines, the classic view of peer influence is that adolescents conform to the expectations and demands of peers in order to make or keep friends and that they risk social isolation by not conforming (Dornbusch 1989). This applies to delinquency and health as well as to educational decisions (see also Sizer 1984; Dornbusch 1989; Cairns and Cairns 1994; Crosnoe 2000; Berndt and Murphy 2002; Chen, Chang, and He 2003). The narrow view that peers consist exclusively of friends has been challenged by evidence suggesting that adolescents perceive that they do not have to modify their behaviors to be accepted by friends. As a result, friends may exert only moderate pressure to adopt

new behaviors (Lightfoot 1997; Harter and Fischer 1999; Bearman and Bruckner 2001).

As an alternative to the influence of existing friends, the preferences of *potential* friends may exert strong pressures through a selection mechanism (Dornbusch 1989; Matsueda and Anderson 1998). That is, adolescents may adopt behaviors that will increase their popularity among peers selecting friends. Adolescents may conform to the behaviors of peers in their wider social networks to garner social capital or to avoid being ostracized and suffering the associated psychological costs (see also Brown 1990; Rubin, Bukowski, and Parker 1997; Akerlof and Kranton 2002). According to Giordano (2003, p. 277), members of the wide network of peers "are more apt to encompass elements of distance and difference, in effect constituting a 'tougher audience' for the developing adolescent. . . . Movement into such relations of contrast requires a developmental 'stretch' that is not as pronounced in the more comfortable world of close friendship." Thus, peers less immediate than existing friends may elicit more dramatic behavioral changes from adolescents than friends do. Furthermore, following Granovetter's (1973) classic observations about the strength of weak ties for adults, we propose that adolescents' peers who are not friends may be influential because they provide important information or opportunities (e.g., knowledge about the nature of a math course or advice on performing well in it).

Though the wider peer network may be a critical source of influence on adolescents, it is difficult to conceptualize. We attempt such a conceptualization by recognizing that the school is an institutional structure that *organizes* adolescent networks. We now turn to the question of how it does so.

The Social Organization of Adolescents in Schools

Traditionally, sociologists of education have described the social organization of schools in terms of academic tracks (Oakes 1985; Gamoran 1987; Lucas 1999; see also Sorenson's [1970] prescient description of the dimensions of social organizations). Certainly, a rich literature has documented the antecedents, processes, and consequences of academic tracking, noting especially the effect of tracking on stratification (Natriello et al. 1989; Hallinan 1991; Useem 1992; Riehl, Pallas, and Natriello 1999; Lucas and Good 2001). Here, we focus on the potential for tracks to organize social relations (Hallinan and Sorensen 1985). Indeed, there is documented evidence that adolescents' academic effort is influenced by the behaviors and beliefs of others in their tracks (Bryk, Lee, and Holland 1993). As we mentioned above, this conceptualization of tracks as intermediate social contexts is relevant to our argument but needs to be up-

dated in the modern age of detracking, in which adolescents are less likely to be assigned to a single level across subject areas and there is little alignment between academic coursework and electives (Stevenson et al. 1994; Friedkin and Thomas 1997; Oakes et al. 1997; Lucas 1999).

With the demise of tracks, there has been a resurgence of emphasis on the social organization of schools in terms of social categories (e.g., Barber et al. 2001; Akerlof and Kranton 2002), harkening to Coleman's (1961) articulation of categories over 45 years ago. Social categories, such as jocks, burnouts, nerds, and others, represent status- or reputation-based groupings within the high school that may or may not align with students' curricula. However, as Akerlof and Kranton (2002) show, social categories are more than merely an alternative conceptualization of social structure, because social categories have salience for adolescents' identities. Specifically, drawing on the link between social categories and identity, Akerlof and Kranton incorporate adolescents' desire to fit into a social category into a model of motivation to exert academic effort.

Social Context and a Formal Model of Motivation in Adolescence

Akerlof and Kranton begin with human capital as the basic motivation for investing in education (Schultz 1961; Becker 1964). Drawing from economics, human capital theorists argue that parents operate as rational actors, calculating pecuniary and nonpecuniary expected returns on investments in their children. Resources are then deployed so as to maximize returns on investment (Steelman and Powell 1991, p. 1506). For example, Steelman and Powell (1991) show that parents are willing to take on the economic burden of college if they desire (and therefore value) education.[2] Adolescents may then pursue education either as influenced or coerced by their parents or because they are themselves aware of the long-term benefits of human capital.

Akerlof and Kranton's great insight (2002, p. 1172) is to infuse identity—defined in terms of "both a student's assigned category and the payoffs associated with self-image" (see also Tajfel 1972; Stryker and Serpe 1994; Davis 2006, 2007)—into a utility function alongside the standard

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[2] Consistent with human capital theory, sociological theories of status attainment attend to the effects of family background on educational and economic advancement, although status attainment theories are typically cast in terms of intergenerational transmission of advantage rather than the motivations of parents and their children.

effects of human capital.[3] For example, Akerlof and Kranton's utility function for nerds, $U_i(N)$, is

$$U_i(N) = \rho \left(w \cdot n_i e_i - \frac{1}{2} e_i^2 \right)$$

$$+ (1 - \rho) \left\{ I_N - t(1 - n_i) - \frac{1}{2} [e_i - e(N)]^2 \right\} . \qquad (1)$$

In the function in (1), the terms associated with human capital are the wage rate per unit of skill (w), the ability of person i (n_i), and the effort of person i (e_i). Thus, the human capital component, represented by $\rho(w \cdot n_i e_i - \frac{1}{2} e_i^2)$, contrasts cost of effort with the return on effort weighted by wages and ability.

The unique terms associated with identity in model (1) are the social status associated with the nerd category, I_N, the identity loss due to an adolescent's distance from the ideal ascriptive characteristics in the nerd category, $t(1 - n_i)$, and the effort adolescents exert to fit into their social categories, $-\frac{1}{2}[e_i - e(N)]^2$, where $e(N)$ represents the ideal effort level (e.g., on academics) for an adolescent who is a nerd. The conformity represented by $-\frac{1}{2}[e_i - e(N)]^2$ is an important example of socially embedded economic behavior (Granovetter 1985, p. 483).

This theoretical specification of the utility function taps the concept of niche picking—adolescents choose social categories in order to maximize their utility in the form of identity.[4] In particular, if an adolescent seeks membership in a high-status category, represented by I_N, to which her attributes are not well suited and thereby reduces her utility, associated with $t(1 - n_i)$, she will have to exert a good deal of effort, calculated as $-\frac{1}{2}[e_i - e(N)]^2$, to maintain a given level of utility. In this way, identity is more than a generic psychological component inserted into a utility function. Identity represents an adolescent's perceived relationship to her group—a psychological link between individual effort and social context within a social organization (Stryker 1980; Davis 2006, 2007). It is thus through identity that Akerlof and Kranton break with traditional economics, which assumes that utility is not situation dependent.

Expressing theory with a utility function has three distinct advantages for building a theory of motivation for academic effort. First, utility functions represent a way of ordering preferences for different quantities of

[3] This dual definition of identity is consistent with Stryker and Burke (2000), although it emphasizes identification with a primary social group as opposed to unique personalities constructed through identifications with multiple groups (Stryker and Serpe 1994).

[4] Akerlof and Kranton (2002, p. 719) use the term "choice" advisedly, recognizing that adolescents might not be aware of choosing.

nonmonetary goods (e.g., human capital, effort, identity). This ordering facilitates an interdisciplinary understanding of motivation, because the ordering operationalizes the assumption of rational action without reduction to monetary terms—utility is a function of psychological fit as well as of human capital.[5] Rationality then implies that actions that produce higher utilities will be more likely to occur.

Second, as Coleman (1995) notes, utility functions can be used to evaluate conditions at equilibrium, thus showing the systemic implications of individual behavior. For example, ideals in social categories can be generated through the aggregate of individual attributes of those who join the social category (see Akerlof and Kranton 2002, p. 1174). Third, the utility function can be maximized with respect to any given quantity to develop expressions for the pursuit of that quantity. For example, Akerlof and Kranton use their functions to express how schools can elicit maximum effort by modifying the standards associated with social categories; later in this section we will maximize utility with respect to effort.

Critique of Akerlof and Kranton's Conceptualization of Social Context in Terms of Social Categories

Though Akerlof and Kranton's formal explanation of influence through identity is elegant, it can be strengthened by rooting it more directly in social experiences. First, social experiences can define a peer group because they attract adolescents with similar interests (Blau 1977; McPherson and Ranger-Moore 1991) and provide adolescents with opportunities for observing and evaluating one another and for engaging in the casual interactions from which friendships can form (Leifer 1988).

Second, common social experiences can also reduce ambiguity in membership of social categories (Akerlof and Kranton [2002, p. 718, n. 3] note that people can have different perceptions of membership). Are the girls who play volleyball, boys who play tennis, and boys who play football members of the same jock group? What socially shared experience is necessary and sufficient to define nerds or burnouts? Without a common

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[5] This assumes that the axioms of coherency or choice have been satisfied (Deaton and Muellbauer 1980). The axioms are (1) ordering of consequences (preferences can be ranked and every preference is ranked, allowing for the possibility of indifference between two options [also known as completeness]); (2) transitivity (if A is preferred to B and B to C, then A is preferred to C); (3) independence (if A is preferred to B then A + C is preferred to B + C); (4) continuity of preferences (this insures that there are no sharp discontinuities of preferences such that very similar inputs will produce very similar utilities); and (5) nonsatiation (utility is nondecreasing in each of its inputs [arguments] and is increasing for at least one input). Other axioms, such as substitutability, monotonicity, and time consistency, may also be considered.

understanding of the membership of social categories, it would be difficult for adolescents to identify potential pools of friends in terms of social categories, and thus influence through the selection process is uncertain. Indeed, Akerlof and Kranton critique their own operationalization of social categories, asking, "How can we know that being in one social category or another reflects anything more than individual tastes and endowments? For example, *there may be no such thing as a group of nerds*: those who are called nerds may just be those who are smarter and more academically inclined. The empirical task is to establish that membership in a social category, independent of tastes, affects behavior" (2002, p. 1176 [emphasis added]).

Third, there is minimal conceptualization in Akerlof and Kranton, or in the social psychology from which they draw (Tajfel 1972; Turner 1985; Turner et al. 1987), of how social categories emerge. One conceptualization is through accumulated interaction (Kirman 1992; Horst, Kirman, and Teschl 2005). But the processes for the formation, dissolution, and growth of social categories are not well specified. Essentially, social categories are treated as exogenous, when in fact they emerge endogenously through individual action in a social context, often around a focal point (Feld 1981).

Fourth, because social experiences can be influenced by school decisions and policies as well as by adolescent behavior, social contexts based on experiences should vary from school to school. For example, the student body of a racially integrated school may differentiate several categories based on race or ethnicity (Bettie 2003), or an urban school may have a "straight edge" category, challenging simplistic understandings of compliance and counterculture (Schwedinger and Schwedinger 1985; Brown 1990; Foley 1990; Burkett 2001; Mohn 2001; Wood 2006). Thus, we must move past early assumptions, such as those in Coleman's *Adolescent Society* (1961), that social categories are constant across schools (see also Coleman 1995). We pursue the above issues by defining social contexts in terms of observable social experiences—the courses that adolescents take.

Local Positions and the Social Organization of Schools

To broaden conceptualizations of the social organization of schools beyond academic tracks or social categories, we introduce local positions. A local position is defined by a set of students within a school who participate in a set of courses that differentiate them from other students in the school. To gain an intuitive feel for local positions, consider the sociogram in figure 1, representing local positions in Miller High School, a moderate-sized rural public school in the Midwest (featured in Field et al. 2006).
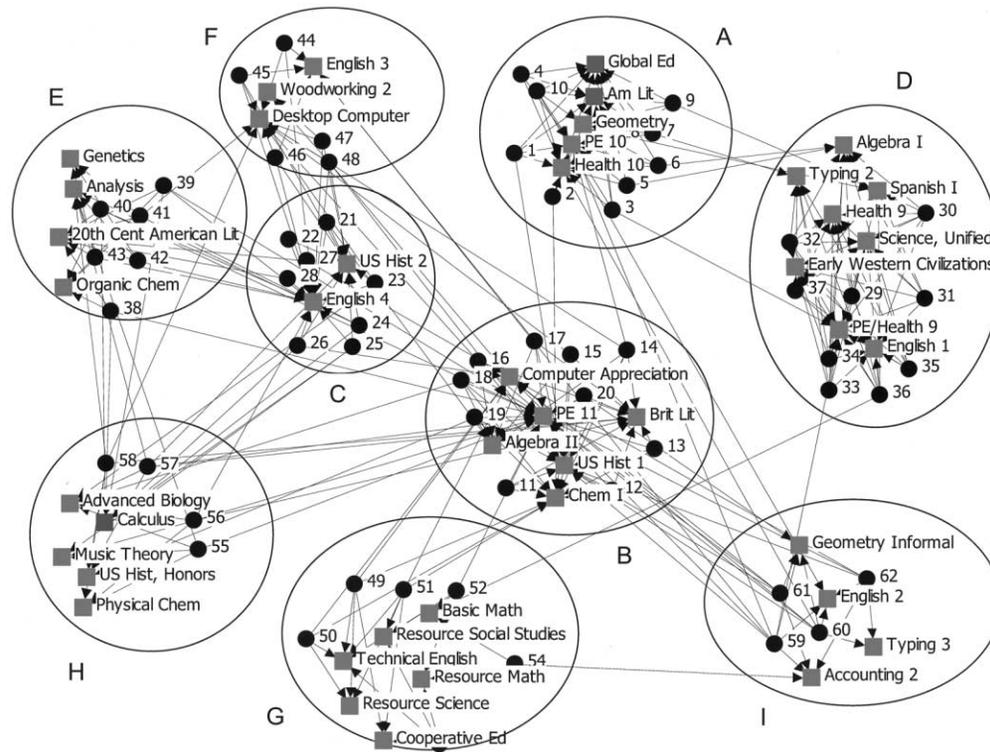
PROOF 10

Fig. 1.—Coursetaking pattern in local positions in Miller High School

In this sociogram, lines connect individuals (represented by dots) to the courses (represented by squares) that they take. The boundaries of the local positions are represented by ellipses containing both individuals and courses.[6]

The figure shows nine local positions, each containing a set of students and focused around a set of courses. For example, local position A contains 10 students and is focused around PE 10, Global Education, Geometry, and American Literature. Of course, students can take courses outside of their local position, as is the case with the members of local position A who take Algebra I, a focal course of local position D. But the focal courses are the experiences that most differentiate members of one local position from others in the school.

Importantly, local positions are not defined solely by course experiences—they are also occupied by students. For example, in Field et al.'s (2006) table 6, males were more represented in local position G (focused around resource courses) and local position H (focused around advanced courses) than in other positions. Those in local position G also had low scores on the Add Health Peabody Picture Vocabulary test (AH-PVT) and a low self-reported likelihood of going to college. In contrast, those (mostly seniors) in local position E focused around advanced courses such as Genetics and Calculus and Analytic Geometry had the highest AH-PVT scores and reported the greatest likelihood of attending college. It is important to note that, although the course positions partly reflect major divisions in student background characteristics, there remains substantial variation within local positions in most of the measures of student attributes. This suggests that the positions are capturing a unique dimension of social experiences not previously revealed by traditional characterizations of the interaction of student background and schooling.

The duality of local positions defined by student members and focal courses (Breiger 1991; Field et al. 2006; Crosnoe et al. 2008) is key to reconceptualizing the social organization of schooling. First, the focal courses within local positions attract adolescents with similar interests, representing the critical commonalities that are the bases of social relationships (Blau 1977; McPherson and Ranger-Moore 1991). But the courses are more than just markers of commonality, because they also provide opportunities for adolescents to observe and evaluate one another

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[6] The data are hypothetical to protect confidentiality, although the number of sample adolescents in each local position and the number of courses taken by the members of each local position reflect actual percentages, with only percentages above 9% represented. Each sample adolescent represents approximately 10 to 15 students in the school. Furthermore, the number of members of the largest local positions was reduced for aesthetic purposes: A was reduced from 37 to 10 members; B, from 25 to 10; C, from 16 to 8; and D, from 18 to 9.

as well as to engage in the casual interactions from which friendships may form (Leifer 1988). Thus, members of local positions constitute an important pool of potential friends (Giordano 2003), and, as a result, can be important sources of influence on adolescents.

Second, the focal courses are shared social experiences that adolescents can use to discern social categories. A set of adolescents who take an unusual course, such as Genetics, meets at a common place and time separate from others in the school. Thus, taking focal courses represents just one of the behavioral strategies in which adolescents engage to make in- versus out-group distinctions (Tajfel and Turner 1979; Palmonari, Pombeni, and Kirchler 1990; Shayo 2005). Furthermore, coursetaking can be measured using student transcripts, which are relatively reliable measures of each student's academic experience, outside of the student's subjective responses to any questionnaire (Akerlof and Kranton 2002). Thus, the courses, as social events, have a prominent place as focal points in our conceptualization of the social organization of the school.

Third, local positions are emergent. That is, individuals do not choose membership in existing social categories, as in Akerlof and Kranton (2002) and much of the social psychological literature (Tajfel 1972; Turner 1985; Turner et al. 1987). Nor do local positions emerge necessarily out of an accumulation of direct interaction (see Davis's [2006, p. 376] description of the sociological approach to identity; see also Kirman 1992; Sen 2002; Horst et al. 2005). Instead, local positions emerge through the pattern of coursetaking in the aggregate, and individuals select into local positions through their particular choices of courses.

Fourth, because local positions emerge through the combination of adolescents' choices of courses and school constraints, they are unique to each school. That is, there could be no local position focused around idiosyncratic courses (e.g., Genetics) if the school did not offer them, nor if a set of students in the school did not take them as part of a larger pattern of coursetaking.

Incorporating Local Positions into the Utility Function

Having conceptualized the social organization of schools in terms of local positions, we reformulate Akerlof and Kranton's utility function to express how adolescents are influenced by members of their local positions. The key is to posit a unique function for members of *each* local position, C. This simple transition to a model for each local position allows the number and type of positions to vary across schools. Thus, in contrast to conceptualizations of a fixed set of social categories that are general across schools, local positions are determined by how students within a particular

school respond to the courses offered by that school. That is, local positions are *embedded* within schools.

Modifying Akerlof and Kranton (2002), a student's utility, given membership in local position C, is

$$U_i(C) = \rho\left(w \cdot n_i e_i - \frac{1}{2}e_i^2\right) + (1 - \rho)\left\{-\frac{1}{2}[e_i - e(C)]^2\right\}. \qquad (2)$$

As in Akerlof and Kranton's utility function, the coefficient associated with human capital (ρ) and the coefficient associated with conformity to a norm $(1 - \rho)$ sum to unity to emphasize the trade-off, with potentially declining marginal returns, for either human capital or conformity.

Notice that we have replaced $I_N - t(1 - n_i) - \frac{1}{2}[e_i - e(N)]^2$ in (1) with $-\frac{1}{2}[e_i - e(C)]^2$ in (2). This modification reflects our conceptualization that local positions are emergent. Therefore, we do not model adolescents choosing local positions in pursuit of social status (associated with I_N), as Akerlof and Kranton do, nor do we express ascriptive fit with $-t(1 - n_i)$, because the local position is not defined so much by a set of desirable characteristics of its members as by their shared experience; simply by virtue of taking the focal courses, one is a member of the local position. Importantly, removing I_N and $-t(1 - n_i)$ does not affect the model that is developed in the next paragraph by maximizing (2) with respect to effort (which is the basis of the models we will estimate).

Although the expressions for utility in (1) and (2) may appear awkward, with squared terms and coefficients of $\frac{1}{2}$, this form of utility function yields simple expressions when maximized with respect to effort (known as the first-order condition for effort). This can also be understood as the minimum amount of effort required to achieve a given utility (Deaton and Muellbauer 1980). Thus, assuming a budget constraint in the form of a fixed amount of time or effort, utility is maximized with respect to effort when

$$e_i = \rho w \cdot n_i + (1 - \rho)e(C). \qquad (3)$$

The implications of (3) are fairly straightforward. Assuming that preferences based on different amounts of $w \cdot n_i$ and $e(C)$ can be ordered and that adolescents act on their preferences, equation (3) expresses the relative importance of the pursuit of human capital, through the terms associated with ρ, and of conformity to the social context of the local position, through the term associated with $(1 - \rho)$. We can then test the effects of local positions (and other social contexts) by estimating the parameters in a model with effort as the dependent variable, as we do in the next section. Moreover, the implications of our model are that the effects of human

capital and social contexts are additive—the effect of one does not depend on the level of the other.

Of course, adolescents may not act rationally in the sense of taking action to achieve their preferred outcomes. The most immediate consequence of irrationality may be that a utility function based only on long-term human capital, without recognizing the short-term effects of identity or conformity to social contexts, is misspecified. In other words, though adolescents are likely partially motivated by long-term goals, their immediate social context may also play an important role in their daily lives (as suggested by Coleman [1996]), influencing choices that ultimately affect long-term human capital. The utility function developed here is an attempt to address this misspecification.

Mechanisms of Influence within Local Positions

Though the model in (2) employing local positions was adapted from Akerlof and Kranton's (2002) models based on identity, in which adolescents act to reduce the psychological cost of nonconformity, adolescents may also be influenced by members of their local positions through two other sociological mechanisms. First, members of local positions may define a reference group (Merton 1957), shaping the very schema, language, and frameworks through which adolescents view their worlds. In turn, these schema can affect decision making, independent of direct interaction between adolescents and members of their local positions. For example, if the members of a local position generally have high aspirations for college, decisions about coursetaking and participation in extracurricular and social activities may be shaped by the draw of college with few explicit references to college on a daily basis.

Second, and perhaps most intriguing, because of the utility of friendship in adolescence, members of local positions may be influential as a potential pool of friends. Adolescents may seek friendships because of the resources they gain from such relationships (Coleman 1990a, p. 128). For example, friendships provide socioemotional resources when an adolescent derives comfort and support from friends, which enhance self-image and identity development, or when an adolescent's popularity among friends enhances his or her social status in the network (Eder 1985). As another example, friendships provide instrumental resources when an adolescent receives help with coursework from friends or when friendships provide a power base from which to rebel against adults (Hartup 1989; Hallinan and Williams 1990; Alfassi 1998; Fuchs, Fuchs, and Kazdan 1999; Mastropieri et al. 2001; Waltemeyer and Balfanz 2002; Crosnoe et al. 2003; McFarland 2004; Riegle-Crumb et al. 2006).

The critical socioemotional and instrumental resources that friends pro-

vide adolescents are a form of *social capital*, which is defined as the potential to gain access to resources through social relations (Portes 1998, p. 7; Lin 1999, pp. 30–31). Implicitly, making friendships represents the accumulation of social capital, and the wider peer network represents the pool, or market, for social capital. Thus, in addition to Coleman's (1995) observation that high schools are particularly convenient venues for studying social status and community, we argue that the attendant pursuit of social capital is particularly salient for adolescents. As a result, adolescents may adopt behaviors to attract friendships from among the pool of potential friends in the local position.

Local Positions and Stratification

Conceptualizations of the social organization of schools have been linked to social stratification. Sociologists have explicitly argued that tracking contributes to stratification, as adolescents with more advantage are assigned to higher tracks, and those in higher tracks receive greater resources from schools (e.g., Hallinan and Sorensen 1985; Oakes 1985; Gamoran et al. 1995; Riehl et al. 1999).

Stratification via social categories is less explicit, although clearly there is an implied academic ranking of nerds above others and burnouts below. Akerlof and Kranton (2002) implicitly justify different expectations for different social categories, akin to tracking, as a way for schools to elicit maximal effort by leveraging adolescents' identities. For example, schools may engage some adolescents by allowing them to affiliate with the burnout category, for which there are lower educational expectations.

Though the tracking literature emphasizes the potentially stratifying effects of resource allocations more than the literature on social categories does, both conceptualizations attribute a high degree of agency to the school leadership (including faculty and administrators) for their ability to affect stratification or elicit effort through resource allocations, standard setting, and symbolic action. But we hypothesize that through local positions, stratification occurs as adolescents respond to the social dynamics among peers as much as to the actions of adults in their schools.

Our conceptualization of stratification draws on the link between local positions as social entities and academic effort. If it is true that local positions have salience as social entities for adolescents, then our model suggests that adolescents will conform to the mean level of effort in their local positions. Over time, this conformity should reduce heterogeneity *within* local positions and increase heterogeneity *between* them. Overall, this will contribute to segmentation through a consolidation of effort and social interaction.

Segmentation by local positions will contribute to stratification by back-

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ground to the extent that local positions reflect differences in family background. And in fact, there is 34% more variation at the local position level than at the school level in parents' education in our data. Thus, the mere structural aspect of local positions and the process of conformity should contribute to stratification.

The utility functions help demonstrate the effect of local positions on stratification. The greater the value of $1 - \rho$, the higher the mean level of effort in the local position the more adolescents are likely to exert effort. Moving from model (3) backwards to model (2), the differences implied by $-\frac{1}{2}[e_i - e(C)]^2$ will be reduced as adolescents maximize utility. This will clearly reduce variation within local positions, because variation is defined by the average value of $[e_i - e(C)]^2$ across all members of the local position. Thus, conformity produces what Becker and Murphy (2000, p. 14) call a *social multiplier effect*, in which individuals not only change their own actions but influence others in their social contexts, creating heterogeneity between contexts (see, e.g., Glaeser, Sacerdote, and Scheinkman 1996).

The utility functions leave open the question of for whom the local position effects might be strongest.[7] The theory of declining marginal utility (or the declining marginal rate of substitutability [Coleman 1990*b*, p. 668]) and constrained optimization suggests that, when an adolescent has multiple possible uses of time, the higher her existing level of math (e.g., the more human capital she already has) the less she would benefit from continued investment in math as human capital. That is, where adolescents have already invested heavily in math, or any other specific knowledge or skill, there will be lower gains from continued investment in that same knowledge or skill relative to other possible uses of time. Therefore, the higher the existing level of an adolescent's math attainment, the less likely she would be to continue investing and advancing in math. This suggests a negative effect of the current level of math on the likelihood of advancement.[8]

Though this analysis is consistent with declining marginal utility of human capital, it ignores the fact that in our model, as in Akerlof and

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[7] We are indebted to an anonymous reviewer for inspiring the following discussion.

[8] We suggest two caveats to this. First, an individual with high returns to math and low returns to social activities may never reach a point within a world with time constraints where the gains from another hour of math do not produce more utility than an hour spent on another activity. This would result in a corner solution in which the student, subject to the constraints of basic activities and reasonable success in other subjects, would only engage in math studies. It is also possible that parts of the utility function may display increasing returns: consider, e.g., the student who with another five hours of study per week would qualify for the "It's Academic" or "Quiz Busters" television team. Her marginal returns would be rising for some range of effort.

Kranton's (2002), adolescents may pursue human capital and the social benefits of conformity through a single behavior in a single realm—academic effort. Thus, an adolescent who is at a low level of human capital may simultaneously realize the human capital benefit of the effort as well as the social and psychological benefits of conforming. Those at the lowest levels of human capital have the most to gain by exerting academic effort in accordance with the norms in their social context. This would predict a negative interaction between an adolescent's current level of math and the mean of those in her local position.

Local Positions, Math Coursetaking, and Gender

Through our theoretical model we assert that adolescents generally will be influenced by members of their local positions. To apply this model to a specific domain of adolescent behavior, we focus on adolescents' coursetaking in math. Linked as it is to college attendance and later job characteristics such as careers in the sciences (Sells 1973; Dossey et al. 1988), math coursetaking is one of the fundamental outcomes in schooling (National Research Council 1989; Oakes 1990; Bryk et al. 1993; Schneider, Swanson, and Riegle-Crumb 1998; Adelman 1999; Lucas and Good 2001).

Rich literatures on tracking and school sector (e.g., Catholic schools, public schools) have documented the myriad ways that schools channel students through the math curriculum (Oakes 1985; Coleman and Hoffer 1987; Gamoran 1987; Gamoran and Mare 1989; Bryk et al. 1993; Stevenson et al. 1994). Yet, within these very real constraints, students do have some choice about which math courses to take or whether to take math at all (Stevenson et al. 1994; Riegle-Crumb 2006). This degree of choice in math coursetaking, net of prior academic experiences and school requirements, is an example of the voluntary academic effort that can be influenced by members of an adolescent's social contexts. Furthermore, although each choice regarding whether or not to advance in math is a discrete event, the series of choices generates the sequence of experiences that produce educational trajectories (Sorenson 1986; Schiller and Hunt 2003; McFarland 2006).

Each decision about whether or not to advance in math also represents the culmination of a set of effects of social contexts on behaviors and beliefs related to math coursetaking. For example, members of a social context can influence an adolescent's personal valuation of math and, therefore, the psychological loss for failure to engage math, the adolescent's sense of the importance of math, or the adolescent's popularity as a result of engaging in math. Each effect can, in turn, influence whether or not an adolescent advances in math. Unfortunately, because many of these factors were not directly measured in Add Health, a full exploration

of these mechanisms is beyond the scope of this study. We argue, however, that these mediating mechanisms reflect many small, day-to-day experiences and voluntary changes that contribute to whether or not an adolescent advances into a higher math course from one year to the next.

Our focus on the influence of members of social contexts on adolescents' math coursetaking reaffirms the need to consider gender as a critical axis of variation. As mentioned earlier, prior research suggests that girls' academic outcomes may be more socially influenced than those of their male peers. This process may be even more heightened with regard to outcomes in the subject of math. Though historical gender gaps (Fennema and Sherman 1977; Armstrong 1981; Elmore and Vasu 1986; Oakes 1990; American Association of University Women 1999; Hyde and Kling 2001; Sadker 2002) have closed somewhat (Xie and Shauman 2003; Planty, Bozick, and Ingels 2006; Riegle-Crumb et al. 2006; Shettle et al. 2007), gender stereotypes and norms, such as ideas about the greater natural inclination of men toward math and science, continue to flourish (e.g., Summers 2005). This being the case, for girls, discussions and decisions about math coursetaking are likely to call forth social messages concerning the status or desirability of math (Correll 2001). In short, girls and boys may still differ significantly in the reasons—especially the social and psychological reasons—for which they take math (Catsambis et al. 1999; Hyde and Kling 2001). Therefore, we estimate separate models for boys and girls, and we focus on gender-specific effects of social contexts (i.e., effects of boys on boys and of girls on girls).

DATA AND MEASURES

Sample

Our base data come from Add Health. Using a stratified sampling design, 80 high schools, most containing grades 9–12 but some containing grades 7 and/or 8 too, were selected from a list of U.S. high schools on the basis of region, urbanicity, sector, racial composition, and size. Nearly all students in these schools (totaling approximately 90,000) completed the In-School Survey in the 1994–95 school year. Of these, 20,745 students, selected randomly (within strata) across high schools (and their feeder school pairs), participated in the wave 1 In-Home Interview in the spring of 1995. In the spring of 1996, a total of 14,738 adolescents (excluding the wave 1 seniors) were followed up on with the wave 2 In-Home Interview, and in 2000–2001, 15,197 wave 1 adolescents were surveyed in the wave 3 In-Home Interview.

Add Health has two key advantages for our analysis. First, it contains extensive survey data regarding adolescent health, work, education, and

other behaviors. Second, Add Health contains network information regarding specific friendship ties. These ties can be combined with survey data to construct more accurate descriptions of an adolescent's friendship network than can be drawn from most large-scale surveys (Dornbusch 1989; Crosnoe, Muller, and Frank 2004).

Our course-level data come from the Adolescent Health and Academic Achievement (AHAA) study, which provides educational data for the Add Health sample (Muller et al. 2007a). Conducted in 2001, AHAA collected the complete high school transcripts for over 12,000 members of the wave 3 sample from the approximately 1,200 high schools they last attended. Combined, AHAA and Add Health contain the raw data needed to explore the effects of human capital, influence through friendship, and influence through local positions and schools that are specified in our theory.

Because the course-level data were obtained with permissions to collect high school transcripts gathered retroactively with wave 3 of Add Health, our analytic sample was considerably reduced from the original wave 1 sample. Preliminary analyses indicated that there were few differences between the samples on a set of background characteristics.[9] The adolescents in our analytic sample may have been slightly more advantaged than the full wave 1 cohort, with AH-PVT (reduced form) scores of 102.83 (versus 100.9 for the wave 1 sample); also, 58% of them came from two-parent families (versus 54% of the wave 1 sample). But demographically, the weighted wave 3 sample we used is identical to the wave 1 sample: 12% Latino/a, 16% black, and with mean of parents' education of 3.8 years (the range is from 0 [representing eight years of schooling or less] through 7 [representing more than college; see app. A for details]). Thus, the small differences in AH-PVT scores and in the percentage of two-parent families were likely not large enough to imply that the results from our analyses misrepresent the Add Health sample, which was itself nationally representative.

Dependent Variable

Our primary dependent variable represents whether or not a student advanced in math between the 1994–95 and 1995–96 school years. Using the AHAA data, Riegle-Crumb et al. (2005) constructed a math level variable with the following categories: (0) no math, (1) Basic/Remedial Math, (2) General or Applied Math, (3) Pre-algebra, (4) Algebra I, (5) Geometry, (6) Algebra II, (7) Advanced Math (Algebra III, Finite Math,

[9] Comparisons were made using wave 1 sample weights for the wave 1 sample and wave 3 weights for the study sample, because transcript data were collected at wave 3.

Statistics), (8) Precalculus (including Trigonometry), and (9) Calculus. The variable for advancement takes a value of 1 if a student's math level increased between 1994–95 and 1995–96, and is 0 otherwise. For further details on this and all other measures, see appendix A.

Because we model advancement in math from one year of high school to the next, we use only those adolescents enrolled in grades 9 and 10 in the 1994–95 school year, most of whom then advanced into grades 10 and 11 in 1995–96. The decisions adolescents make regarding math coursetaking in their first two years of high school are the most critical (Catsambis 1994; Stevenson et al. 1994; Schneider et al. 1998; Schiller and Hunt 2003), as decisions and performance in the earlier years of high school explain a large portion of the variation in final math sequence achieved (Schiller and Hunt 2003; Riegle-Crumb 2006). Moreover, our theory implies that adolescents will be more responsive to their social contexts in the earlier years of high school, as they form their identities.

Independent Variables

Human capital.— Standard models of human capital link long-term earnings to educational attainment (Schultz 1961; Becker 1964). But long-term earnings have not yet been realized, and therefore the potential of education is uncertain, when adolescents are deciding how much effort to exert in high school. Therefore, we use Add Health to prospectively measure the value adolescents and their parents assign to human capital prior to making educational decisions. In particular, we use a measure of each adolescent's college aspirations as an indicator of the human capital value that adolescent assigns to education. Furthermore, human capital is often framed in terms of parents' investment in education (Schultz 1961; Becker 1964), and parents' aspirations for their children have been directly linked to more standard measures of human capital; the more parents desire college for their children, the more willing they are to assume debt to pay for college (Steelman and Powell 1991). Although Add Health does not contain a direct measure of parental aspirations, it does include a measure of parents' disappointment over their children's failure to attend college, which we include as a measure of the value of human capital.

Last, we measure attained human capital in terms of current level of math in 1994–95. A negative effect of current level of math on advancement would be consistent with a declining marginal utility of math.

Social context: peers' mean levels of math.—Our theory concerns the effects of norms of social contexts. We define each norm in terms of the mean level of math coursetaking of the corresponding context in 1994–95. These include the mean math levels of friends (as nominated by either member of a pair of adolescents in the In-School or wave 1 surveys),

members of the local position, and members of the school. Furthermore, we note that adolescents might be inclined to conform to the behaviors of those in their courses, regardless of the organization of adolescents and courses into local positions. These coursemates serve as potential weak ties (Granovetter 1973), or acquaintances that could direct behavior by providing information about math courses or opportunities to support those who choose to advance in math. We therefore include mean math level of coursemates (weighting the courses in inverse proportion to their enrollments [see app. A for details]). The influence of coursemates captures dyadic influences through coursetaking to complement the group effect of the local position. We then model only with the gender-specific mean (i.e., the mean math level of girls in the local position is used to model whether a girl advances in math).

Because gender is an important aspect of adolescent identity (Eder 1985; Akerlof and Kranton 2002) gender-specific roles are extremely salient. Therefore, we calculate separate means for each gender in each context other than friends. That is, we calculate the mean math level of girls who are coursemates, members of the local position, and members of the school, and then do the same for boys. We do not calculate separate means for friends who are boys and friends who are girls, because there would have been too much missing data (more than 40%). Instead, we argue that all others who have become friends are equally important regardless of their gender.

Prior educational experiences.—The decision to advance in math or not likely depends on an adolescent's prior educational experiences. Therefore, we control for whether a student has been retained, to account for previous educational experiences, and for math grade point average and grade level to account for subject-specific and immediate educational experiences.

Background.—To control for basic demographic effects, we included terms for whether an adolescent is Latino/a, black, or Asian. The reference category was "non-Latino/a white," with not enough observations in the "other" category to sustain a stable estimate. Only the effects of Latino/a and black are reported in our tables. We also control for parents' education to account for potential educational experiences in the home.[10] In exploratory analyses, parental education was dichotomized, with a value of 1 indicating a college education or more and a value of 0 for less than a college education (46% of the parents in sample had attended at least some college).

Other controls were excluded from the final models because they did

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[10] We did not control for parents' income, because it had substantial missing data (19%) and was less directly related to educational outcomes than parents' education.

not affect our primary inferences and were not statistically significant. These included the adolescent's score on the AH-PVT (representing academic potential); an indicator of whether the student came from a two-parent family (representing available resources in the home); hours worked for pay during a typical nonsummer week (representing a potential distraction from academic effort); and sense of belonging in school (representing immediate academic motivation).

THE MULTILEVEL MODELS TO BE ESTIMATED

To test our theory, we estimate multilevel models (i.e., models with random effects) of advancement in math with adolescents nested in local positions within schools.[11] Unlike fixed-effects models, multilevel models do not merely control for effects of social contexts (e.g., local positions or schools), because they include the capacity to simultaneously test effects at multiple levels (e.g., the effects of college aspirations at the individual level and of the mean math level at the local position level), as well as cross-level interactions to find, for example, a negative interaction between an adolescent's current level of math and the mean of those in her local position (see Raudenbush and Bryk 2002).

Because our outcome is advancement in math between the 1994–95 and 1995–96 academic years, the level 1 model specifies a logistic regression. Then, using the notation of Raudenbush and Bryk (2002) but modifying the subscripts, the level 1 model for whether a female adolescent i in local position c in school j advanced in mathematics is

$$\ln\left[\frac{p(\text{advanced})_{icj}}{1 - p(\text{advanced})_{icj}}\right] = \pi_{0cj} + \pi_{1cj}\text{college aspirations}_{icj}$$

$$+ \pi_{2cj}\text{parent disappointment over no college}_{icj}$$

$$+ \pi_{3cj}\text{own level of math in 94–95}_{icj}$$

$$+ \pi_{4cj}\text{mean 94–95 math level of friends}_{icj}$$

$$+ \pi_{5cj}\text{mean 94–95 math level of female coursemates}_{icj}. \quad (4)$$

Note that the terms in (4) are more elaborate than the reduced form of the utility function in (3). For example, π_{1cj}, π_{2cj}, and π_{3cj} represent effects associated with human capital, generally associated with ρ in the utility function, and the parameters π_{4cj} and π_{5cj} are two examples of terms

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[11] For all analyses, we weighted the individual level with the AHAA transcript weights and the school level with Add Health school weights (Chantala 2006).

associated with $1 - \rho$ in the utility function, representing the effect of mean 94–95 math level of friends and female coursemates, respectively.

The typical empirical work on human capital is essentially retrospective, testing the relationship between educational attainment and eventual or expected career trajectories, wages, or employment. But to operationalize the more immediate effects of local positions, we must carefully consider the timing of the behaviors that lead up to the action of advancing in math or not. In particular, we theorized that members of an adolescent's social context could influence a set of day-to-day behaviors that culminated in advancement in math. Relative to advancement from 1994–95 to 1995–96, therefore, we consider the relevant local positions to be from the 1994–95 school year. Adolescents were exposed to members of their local positions during that academic year, leading up to their potential advancement in math between that year and the next.

Effects of the 1994–95 local positions are then specified through a level-2 model of the level-1 intercept, π_{0cj}:

$$\pi_{0cj} = \beta_{00j} + \beta_{01j}\text{mean 94–95 math level of girls in local position}_{cj}$$

$$+ \ r_{0cj}. \tag{5}$$

Thus, β_{01j} represents the effect of the mean math level of girls in the local position on girls' tendency to advance in math (and the error terms, r_{0cj}, are assumed to be identically and independently normally distributed with mean zero and variance τ_π). Similarly, each of the level-1 slopes can be modeled at level 2, although in our main models we model each slope as a function of only an intercept. For example,

$$\pi_{1cj} = \beta_{10j}. \tag{6}$$

Note also that the residual variation for each coefficient was fixed to zero.

To test for a negative interaction between an adolescent's current level of math and the mean of those in the local position, we model the slope representing the effect of current level of math as a function of the local position mean. In particular,

$$\pi_{3cj} = \beta_{30j} + \beta_{31j}\text{mean 94–95 math level of girls in local position}_{cj}. \tag{7}$$

Thus, β_{31j} will be negative if the effect of the mean 94–95 math level of girls in the local position is stronger the lower a girl's own level of math in 1994–95 is.

School-level effects are then introduced at level 3 by modeling the level-2 intercept. In particular,

$$\beta_{00j} = \gamma_{000} + \gamma_{001}\text{mean 94–95 math level of girls in school}_j + u_{00j}. \tag{8}$$

Here, γ_{001} represents the effect of mean 94–95 math level of girls in school

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j on the tendency for girls to advance in mathematics from the 1994–95 school year to 1995–96 (the error terms, u_{00j}, are assumed to be identically and independently normally distributed with mean zero and variance τ_β). Each of the other effects from level 2, including the coefficients for the cross-level interaction in (7), was modeled only as a function of an intercept.[12] For example,

$$\beta_{10j} = \gamma_{100}. \tag{9}$$

ANALYTIC APPROACH

Our model posits local positions as a critical mesolevel in the social organization of adolescents in schools. Therefore, we begin by identifying local positions in each of our schools. To do so we employ an algorithm recently developed by Field et al. (2006) for identifying nonoverlapping clusters from affiliation networks (see details in app. B). The raw data for the algorithm are the indicators of the courses each student took, weighted in inverse proportion to course size. Drawing on an extension of p* social network models to affiliation networks (Skvoretz and Faust 1999), the algorithm maximizes the increase in the odds that an actor participates in an event within the same cluster versus an event outside the cluster. In relation to transcript data, the actors are adolescents, the events are courses, and the identified clusters are local positions in which coursetaking is concentrated.

Critically, Field and colleagues' (2006) network algorithm can be applied uniformly across all Add Health schools because it requires no subjective input or interpretation unique to a data set. Specifically, because the algorithm dynamically generates new clusters and dissolves old ones as needed during iterations, and because the algorithm maximizes a single model-based criterion, researchers need not specify the number of clusters or interpret multiple solutions for a given data set.[13] Ultimately, we identified 1,173 local positions across 78 schools, with the typical position containing almost 10 AHAA students. Given that each student in the

[12] All independent variables were centered around their gender-specific sample means. Thus, local position effects have been adjusted for differences in the compositions of the local positions as measured by individual-level variables. Furthermore, local position effects of math sequence are adjusted for an individual's own level of math sequence, effectively making the local position effect that of others in the local position. Similarly, school effects are adjusted for mean local position effects, effectively making school effects those of other local positions in the school.

[13] Though the rules for dissolving and creating new local positions are essentially heuristic, the algorithm has been shown to be effective in recovering most of an optimal structure (Frank 1995; Field et al. 2006)

wave 3 study represents about six in the school, local positions contain, on average, about 60 students, a size consistent with our description of local positions as defining an intermediate social context between immediate friends and the school at large.

We next calculate simple descriptive statistics separately for males and females for all of the adolescents in our sample. Then we estimate the models separately by gender. The analyses for girls do not include one all-boys school, and the analyses for boys do not include one school that did not contain any boys in our grade range.

We establish a baseline for the multilevel models by estimating an unconditional model of advancement in math so that we may report the variation that can be attributed to local positions (represented by τ_π) as opposed to schools (represented by τ_β).[14] Next, we estimate the effects of value of human capital (college aspirations, parents' disappointment over no college, and level of math in 1994–95) as well as the effects of peer mean levels of math in each social context. We then estimate models that include cross-level interactions to assess the extent to which the effect of the local positions depends on perceived value of human capital and existing level of math in 1994–95. We use the extremely precise Laplace approximation to the likelihood employed by HGLM (Raudenbush, Yang, and Yosef 2000) to reduce bias in estimates and especially standard errors.

There was considerable data missing for friends' level of math: we had no information on this variable for 16% of girls and 18% of boys.[15] There was also a smaller amount of missing data on coursemates' levels of math and other covariates. Therefore, we used the SAS PROC MI procedure to impute five data sets using a Markov chain Monte Carlo method (with a Jeffrey prior), constraining values for each variable to the range that occurred in the observed data. The imputed values were based on other nonmissing variables in our models. We calculated overall effects and standard errors across the imputed data sets as described in the HGLM guide and in Rogers et al. (1992).

After estimating effects of local positions on advancement in math, we estimate the implications for variance in math level within local positions, between local positions, and between schools. These models include controls for background characteristics and value of human capital that might be causally prior to membership in the local position, although the interpretations do not depend on these controls being in the model.

[14] A separate variance is not estimated at level 1, because variance is not constant for dichotomous outcomes—hence the need for the logistic regression.

[15] Friends' mean math level was missing typically because none of the respondent's friends were in the wave 3 sample.

RESULTS

Descriptive Statistics of Key Variables

Overall, 76% of girls in the sample advanced in math between the 1994–95 and 1995–96 school years (see table 1), while 71% of boys advanced. Supplementary analysis, not shown in table 1, indicated that, of all those who did advance, 67% advanced only one level. Approximately 5% advanced from Pre-algebra to Algebra I, 35% from Algebra I to Geometry, and 20% from Geometry to Algebra II. These percentages reflect normative movement through core courses in the U.S. high school mathematics curriculum (Schiller and Hunt 2003).

With regard to valuing human capital, girls had slightly higher college aspirations than boys (a mean of 4.5 versus 4.4), and girls' parents and boys' parents expressed nearly equal disappointment over their children's failure to attend college (a mean of 1.7). For girls, the average level of math in the 1994–95 school year was approximately 4.2, and for boys it was 4.0, a value representing Algebra I enrollment.

In terms of social contexts, girls' friends had slightly higher levels of math coursetaking than did boys' friends (4.4 versus 4.3). Similarly, girls' female coursemates, fellow members of local positions, and schoolmates had slightly higher levels of math than boys' male peers did in the same social contexts.[16] The relative academic advantage of girls also applies to individual academic factors: approximately 15% of girls, as opposed to 24% of boys, had been retained prior to high school, and the math grade point average of girls was 2.36 while boys' was 2.13. Finally, girls and boys came from similar backgrounds (11%–12% Latino/a, 15%–16% black, parents' education of 3.7–3.8 years).

Predicting Math Advancement

In an unconditional multilevel model for girls, the variance component was .53 for local positions (about 46%) and .63 for schools (about 54%); for boys, the variance component was .64 for local positions (about 64%) and .34 for schools (about 34%). While the estimates of girls' and boys' proportional variation at the local position are different, the difference (about .11) is half a standard error (about .22) for the local position variance component for either boys or girls, and so we do not interpret the difference as significant. In either case, these preliminary results confirm

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[16] The values for coursemates are near zero because math sequence was centered before calculating coursemates' mean levels, to reduce collinearity. The weights for coursemates were standardized to preserve the metric, producing a roughly comparable standard deviation for the math levels of the individual, friends, and coursemates.

TABLE 1
Descriptive Statistics for Focal Variables, Ninth- and Tenth-Graders

	Girls			Boys		
	Mean	SD	N	Mean	SD	N
Advancement in math (1994–95 to 1995–96)	.762	.396	1,903	.711	.429	1,733
Human capital:						
College aspirations	4.507	.874	1,969	4.379	1.016	1,809
Parents' disappointment over no college	1.696	.639	1,770	1.725	.700	1,622
Level of math in 1994–95	4.225	1.406	1,972	4.015	1.521	1,809
Peer mean levels of math (1994–95):						
Friends	4.442	3.939	1,975	4.261	4.193	1,816
Coursemates—girls	.069	1.477	1,975			
Coursemates—boys				−.236	1.903	1,816
Local position members—girls ...	4.408	2.008	1,035			
Local position members—boys ...				4.355	1.980	1,035
Schoolmates—girls	4.422	.847	78			
Schoolmates—boys				4.270	.909	78
Prior educational experiences:						
Ever been retained	.148	.331	1,975	.244	.411	1,816
Math grades for 1994–95	2.362	1.090	1,910	2.130	1.114	1,739
Grade level in fall 1994	9.542	.463	2,055	9.518	.477	1,891
Background:						
Latino/a	.111	.293	1,975	.119	.310	1,816
Black	.160	.342	1,975	.154	.346	1,816
Asian	.032	7.067	1,975	.055	9.435	1,816
Parents' education	3.724	1.391	1,975	3.820	1.456	1,816

our proposition that math coursetaking varies considerably *within* schools.

Table 2 presents the results of three-level models predicting advancement in math with factors representing human capital, peer mean levels of math, prior educational experiences, and background for both boys and girls. In model 1 (main effects), the effects of human capital at the individual level were clear and as expected. Both boys and girls were more likely to advance in math the higher their college aspirations and the more disappointed their parents would be if they did not attend college. Furthermore, the effect of already-acquired human capital, in the form of current math level, was consistent with declining marginal utility: the higher an adolescent's existing level of math, the less likely that adolescent was to have advanced to a higher level.

Turning to the effects of peers, we find that girls were more likely to advance in math the higher the mean level of math coursetaking of girls in their local position and the higher the mean of girls in the school. We

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TABLE 2
Effect of Social Contexts on Advancement in Math between the 1994–95 and 1995–96 School Years, by Gender

Independent Variable	Girls[a]		Boys[b]	
	Model 1	Model 2	Model 1	Model 2
Human capital:				
College aspirations	.262**	.257**	.332***	.330***
	(.091)	(.097)	(.069)	(.075)
Parents' disappointment over no				
college	−.312***	−.314**	−.240*	−.251*
	(.094)	(.096)	(.113)	(.120)
Own level of math in 1994–95	−.315***	−.406***	−.198***	−.251***
	(.056)	(.058)	(.059)	(.066)
Peer mean levels of math (1994–95):				
Friends	.035	.032	.028	.031
	(.023)	(.024)	(.038)	(.037)
Coursemates—girls	−.001	−.011		
	(.060)	(.067)		
Coursemates—boys			.133	.074
			(.109)	(.113)
Local position—girls	.245***	.243**		
	(.074)	(.077)		
Local position—girls × own level				
of math in 1994–95		−.135***		
		(.031)		
Local position—boys			.019	−.007
			(.109)	(.115)
Local position—boys × own level				
of math in 1994–95				−.077*
				(.031)
School—girls	.393*	.455*		
	(.198)	(.201)		
School—girls × own level of math				
in 1994–95		−.105*		
		(.046)		
School—boys			.201	.346
			(.206)	(.230)
School—boys × own level of				
math in 1994–95				−.159***
				(.046)
Prior educational experiences:				
Ever been retained	−.527**	−.513**	−1.124***	−1.138***
	(.164)	(.171)	(.261)	(.267)
Math grades for 1994–95	.843***	.871***	.868***	.911***
	(.089)	(.090)	(.081)	(.086)
Grade level in fall 1994	−.493**	−.342*	−.242	−.096
	(.156)	(.162)	(.207)	(.222)

TABLE 2 (*Continued*)

	Girls[a]		Boys[b]	
Independent Variable	Model 1	Model 2	Model 1	Model 2
Background:				
Latino/a	−.109	−.134	−.313	−.376
	(.317)	(.366)	(.278)	(.282)
Black	−.138	−.163	.073	.025
	(.233)	(.234)	(.297)	(.303)
Parent had some college	−.138	−.113	−.171	−.167
	(.172)	(.187)	(.218)	(.222)
Intercept	1.565***	1.763***	1.460***	1.658***
	(.156)	(.161)	(.168)	(.179)

Notes.—Models use multiple imputation to account for missing data. Numbers in parentheses are standard errors.

[a] $N = 1,973$.

[b] $N = 1,533$.

* $P \leq .05$.

** $P \leq .01$.

*** $P \leq .001$.

will interpret this effect further below. Girls' advancement was not statistically significantly related to mean math levels of girls who were friends or girls who were coursemates, although the estimate for friends was in the expected direction and larger than its standard error.[17]

In contrast to the coefficients for girls, the estimated effect of the mean of the local position was not statistically different from zero for boys. Moreover, the estimate was about one-eighth of its standard error and was statistically different from the coefficient for girls (using the test advocated by Cohen and Cohen [1983, pp. 55–65]). Furthermore, none of the estimates of the effects of peers even remotely approached statistical significance.

With regard to previous educational experiences, both boys and girls were less likely to advance in math if they had ever been retained and were more likely to advance the higher their math grade. In addition, girls were less likely to advance the higher their grade level, and the estimated coefficient was in the same direction for boys. Finally, none of the effects for background were statistically significant for boys or for girls.[18]

[17] This is consistent with Riegle-Crumb et al. (2006), who found that same-sex friends' grades had a significant effect on advanced coursetaking for females (but not for males).

[18] The coefficient for parents' college attendance was statistically significant in a zero-order relationship for each gender, but the coefficient was reduced essentially to zero once we controlled for other covariates, especially math grades and parents' disappointment over no college.

Local Positions and Stratification

Figure 2 shows the implications for advancement for 100 girls in local positions with a starting mean level of math of Geometry in 1994–95, versus 100 girls in local positions who started with a mean level of Pre-algebra (the mode being Algebra). Between 1994–95 and 1995–96, about 88 students in the higher (Geometry-based) local positions are predicted to advance, whereas only 76 from the lower (Pre-algebra-based) local position are predicted to advance. The initial differences contribute to stratification in two ways. First, because more students in the high group advanced in the first year, more are eligible to advance in the second year (assuming that students who stop taking math do not start again [Stevenson et al. 1994; Ma and Willms 1999; Schiller and Hunt 2003; McFarland 2006]). Second, the more students in the local position who advance in math, the higher the mean level of math, and, therefore, the larger the proportion who advance to the next level in conformity with the local position mean.

The net effect of initial differences between the two types of local positions in mean level of math is that over the three years from 1994–95 to 1996–97, about 77 from the higher group are predicted to advance, as opposed to 61 from the lower group, a difference of 16 students. As a result, only 61 of those in the Pre-algebra-based local position are predicted to compensate for the initial gap between themselves and those in the Geometry-based local position by their junior year. Moreover, because of the national representativeness of the data, these differences apply to tens of thousands of adolescents in high schools in the United States in the mid-1990s.

Figure 3 shows the empirical implications of stratification in terms of estimated variation attributed to individuals, local positions, and schools in highest math levels attained by 1994–95 and 1995–96 for girls (controlling for background characteristics and the value of human capital). Figure 4 shows the same for boys. In 1994–95, 35% of the variation in girls' math levels can be attributed to local positions. While there is still considerable variation (55%) within local positions, note that without local positions our understanding would be that 10% of the variation is at the school level and the other 90% is within schools—results that are within the typical range of the variation of achievement or attainment (Frank 1998). Instead, we recognize that approximately 44% of the variation within schools can be attributed to an emergent but observable sociological entity: the local position. Similarly, for boys, 35% of the total variation in math level in 1994–95 can be attributed to local positions, although approximately 20% of the remaining variation is between schools, still well within the standard range (Frank 1998).
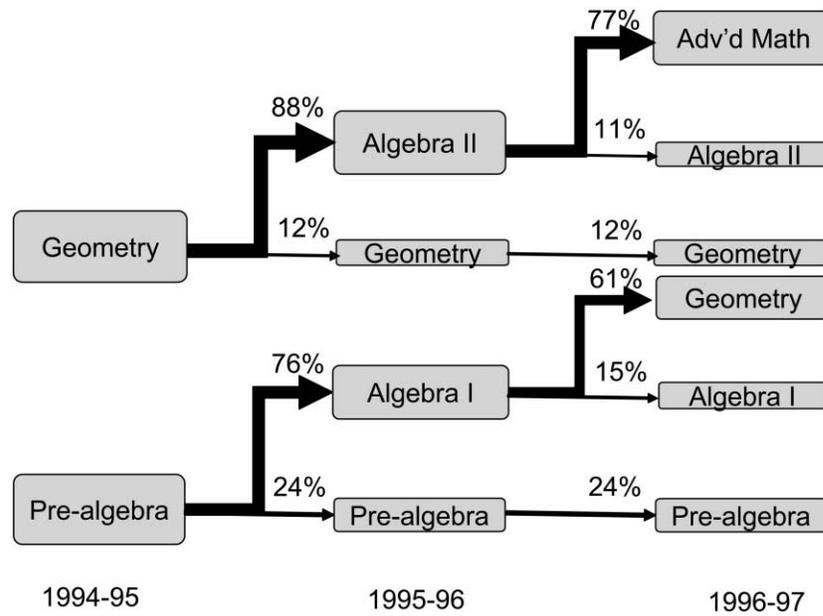
FIG. 2.—Predicted increased stratification between members of low and high local positions on account of conformity to local position means (for girls).

The second panels in figures 3 and 4 show that each component variation roughly doubles in a single year (e.g., the variation attributed to local positions for girls increases from .66 in 1994–95 to 1.45 in 1995–96). But the local positions provide some theoretical insight into how the social dynamics within schools contribute to stratification. In particular, because the variances in 1995–96 are roughly proportional to the variances in 1994–95, local positions are responsible for roughly one-third of the *increase* in variation. Thus, though differences between schools may increase variation, they are still responsible for only a relatively small proportion of the variation in math level. On the other hand, while variation at the individual level is still the largest share, the individual attributes responsible for this variation are difficult to identify or modify. In contrast, local positions represent some portion of the variance that is structural and that heretofore would have been attributed to individuals.

The Interaction of the Local Position's Mean Level of Math and the Adolescent's Math Level

The effects of local positions do not interact strongly enough with our measures of the value of human capital for boys or girls to reject the null
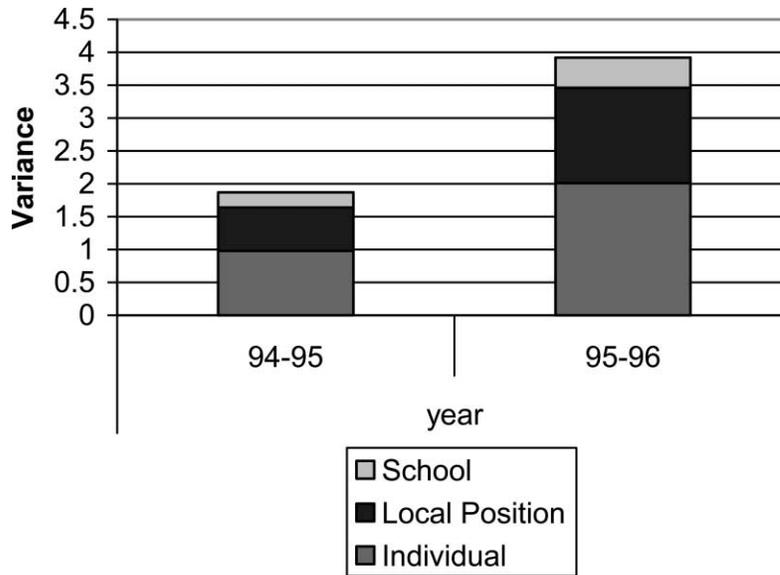
PROOF 32

FIG. 3.—Change in variances from 1994–95 to 1995–96 in mathematics levels for girls, controlling for background.
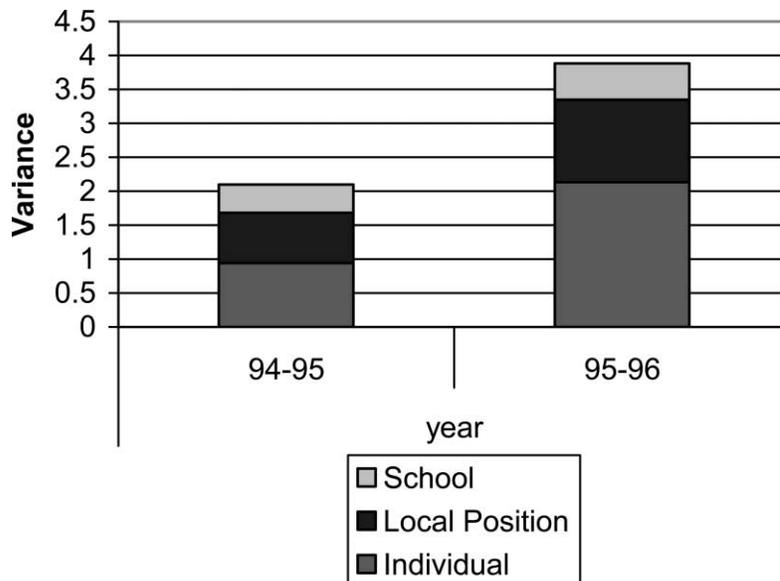

FIG. 4.—Change in variances from 1994–95 to 1995–96 in math levels for boys, controlling for background.

hypothesis of an additive model (all p values $> .2$). But as shown in model 2 of table 2, the effect of local positions has a negative and strong interaction with an adolescent's existing level of math. The implication is that the conformity effect reduces heterogeneity within local positions by pulling up those who are below the mean level. Moreover, this interaction occurs for both boys and girls, even though there is no main effect of the local position mean for boys.

The interaction effect shown in figure 5 is for girls in low (e.g., Pre-algebra) and high (e.g., Geometry) math levels for local positions with low and high mean levels of math (with all other variables in the model controlled and centered around their grand means). As can be seen, the effect of the local position mean is stronger for those who start at lower levels of math; for girls who start in Pre-algebra, the probability of advancing in math increases from .84 in the Pre-algebra local positions to .92 in the Geometry local positions (an increase of about .08), while for girls at high levels of math the effect of the local position mean increases advancement from .78 to .82 (an increase of only .04). Therefore, the effect of the mean of the local position is primarily to pull up those at the lower end of math rather than to pull down those at higher levels.

DISCUSSION

What happens in high school lays the groundwork for adult life, but adolescents may not always take such a long view when deciding what to do—and how to do it—during high school. What may be more important to them is what is immediate in chronological and social terms. In this study, we have shown that though math coursetaking has implications for adolescents' future education and occupations, girls in particular factor in norms of their peers in choosing whether or not to advance in math. As a consequence, norms contribute to the fundamental social dynamics that affect educational motivation, attainment, and stratification.

The key to testing the effects of peer norms in this study was to conceptualize the social organization of the school in terms of local positions, clusters of students who take courses together. We found that girls were more likely to advance in math in 1995–96 the higher the level of math taken in 1994–95 by other girls in their local position. This finding is consistent with our characterization of group effects of the local position because we controlled for dyadic peer effects defined by coursemates and friends as well as for the broader organization context of the school.

The strong effect of the local position norm suggests that local positions are quite salient as a social context, at least for girls. This salience may
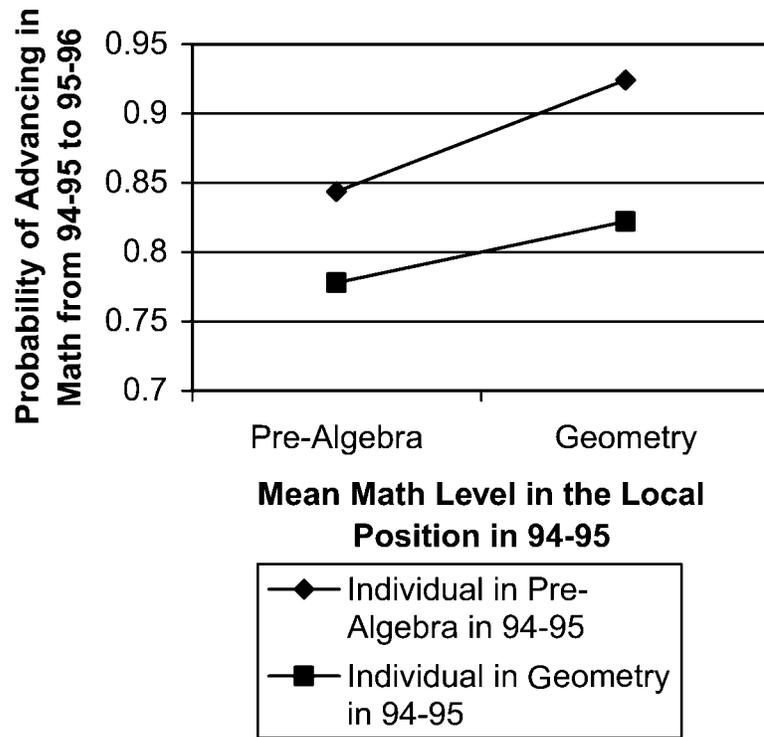
F_{IG}. 5.—Interaction of local position mean and mean individual level of math in 1994–95 on advancing in math between 1994–95 and 1995–96 for girls.

emerge as members of local positions administer social sanctions to per-petuate group norms or by collectively defining a basis for reference. This accentuates their influence beyond the mere informational effects of a weak tie (Granovetter 1973). When group processes based on norms and reference are present, local positions constitute *milieus* (Coleman 1995), representing small segments of adolescent subculture that have an im-mediacy in adolescents'—especially girls'—lives.

The difference between boys' and girls' responses to members of their local positions is quite striking, given the similarity between the two genders with respect to the other effects. The differences in the effects of local positions are consistent with extant literature that describes girls as generally more responsive to their social contexts than boys are (Gilligan 1982; Eccles et al. 1984), and particularly to certain contexts in which gender beliefs are salient (Correll 2001).

It may be that boys are less responsive to group phenomena than girls because boys draw less of their identity from membership in the social

group, are less aware of the social group, or form their identity from affiliations other than coursetaking (e.g., sports participation). This is not, of course, to say that girls are less rational or more affective in their decision making than boys. Girls' responsiveness to group norms likely contributes to the resources they can access as well as to the cohesiveness of their social groups. Though we cannot test these propositions with our data, we include group conformity in a utility function alongside the individualistic pursuit of human capital to emphasize that adolescents, like others, must adjudicate between individualistic pursuit and conformity to group norms.

Though our theory and new methodological work focus on the effects of peers, the effects of human capital are clearly strong and present and are in expected directions according to previous research (Schultz 1961; Becker 1964). Both boys and girls are more likely to advance in math the higher their college expectations and the greater their parents' disappointment if they were not to attend college. Thus, those who pursue and value education are more likely to exert academic effort, in the form of math coursetaking, in high school. More than just consistent with the theory of human capital, our findings on the effects of the value of human capital on math coursetaking strongly support our contention that adolescents (acting on their own and in response to their parents) have considerable agency in shaping their social contexts through the courses they choose to take. Absent such choice, math coursetaking would be primarily a function of prior educational experiences (e.g., previous math grades) and socioeconomic background (e.g., parents' education).

Our utility function allows us to formalize this adolescent agency. Because the model for effort in (3) was generated from the utility function in (2), we can trace back from the parameter estimates in our results to a theory of motivation in which agency is explicitly attributed to the adolescent. Positive coefficients associated with adolescents' and parents' expectations are consistent with adolescent utility that includes the long-term value of education as human capital. Furthermore, the positive effect of the local position (and school) mean is consistent with a utility function for girls that includes the importance of conforming to the peers in their local position. Also, because the effects of the value of human capital do not interact with the mean of the local position, our findings are consistent with an additive model of utility, as in (2).

Our conceptualization of local positions defined by coursetaking recognizes adolescent agency in constructing the social organization of the school. Given constraints defined by a school's course offerings, an adolescent's course choices locate her in the social structure defined by the aggregate of choices. Thus, local positions are not exogenous social structures, and we can learn more about the emergence of social structure by

examining adolescents' motivations for choosing courses other than the math courses that were the focus of this study.

Though our model and findings reflect individual motivations, individual behavior has systemic implications in terms of stratification. Thus, we do not attribute stratification solely to the careless or deliberate actions of administrators or school officials, to intergenerational transmission of advantage, or to unseen societal forces (Bowles and Gintis 1976, 2002). Instead, stratification between local positions can occur among girls merely because there are differences in girls' math levels as they enter high school, girls experience the local position as a social milieu, and girls respond to the norm of math coursetaking in their social milieus. Furthermore, similar social dynamics apply to stratification between *schools*, as girls also respond to the mean in their schools.

To say that local positions and conformity effects contribute to stratification is not to diminish the responsibility of schools to generate egalitarian outcomes. On the contrary, our findings demonstrate that stratification is likely to occur in schools with laissez-faire practices.

So what can schools do? First, they can alter avenues for social stratification through their structuring of courses. For example, by making limited use of the vocational track, Catholic schools may reduce segregation that might otherwise occur by track (Coleman, Hoffer, and Kilgore 1982; Bryk et al. 1993; Kubitschek and Hallinan 1998). Second, schools can influence the activities and courses in which adolescents choose to participate. For example, Moody (2001*a*) suggests that schools can reduce racial segregation by actively encouraging adolescents of diverse backgrounds to participate in a broad range of extracurricular activities. Third, the strong effect of local positions for girls at the lowest levels of math suggests that schools can leverage conformity to induce greater effort. This can be done by enhancing the status of certain activities through symbolic action. For example, Coleman (1995) suggests enhancing the status of math, in relation to athletics, through math olympiads. In this way, schools can make some activities more attractive than others and thus encourage equal participation across the student population.

Like any empirical study, this investigation has limitations that deserve mention. First, we do not know how well our theory extends beyond math coursetaking in regard to academic effort. For example, we do not know how much adolescents are influenced by members of local positions with respect to academic effort in learning foreign languages or literature, or with respect to deviant behaviors such as alcohol use or nonacademic behaviors such as sports participation. Nor do we know for which behaviors local position norms will be more salient for girls than for boys, and vice versa. Though we carefully selected math coursetaking because of its importance for future education and careers, it is worth exploring

whether the conformity effects of local positions apply across a range of behaviors that constitute acceptance and adolescent identity. For example, perhaps behaviors intended to broaden the potential pool of friends (e.g., use of alcohol) would be more influenced by school-level norms (cf. Giordano 2003). Furthermore, other behaviors might evoke less gendered responses (Ridgeway and Correll 2004). We hope that the theoretical models based on utility that we have built here will serve as a guide for studies of other behaviors that might be motivated by a range of individual factors and social contexts.

Second, because the transcripts provide information about courses (e.g., PE 10) rather than classes (e.g., PE 10, second hour with Ms. Smith), common coursetaking indicates only an increased *probability* of interaction among adolescents. One mitigating factor is that adolescents who take the same unusual courses within a local position are more likely to take other courses together because of constraints in the master schedule. Furthermore, we partially compensated for this potential problem by weighting courses in inverse proportion to their size. But optimally, we would have data on classes as well as courses.

A final limitation is that our access to only a subsample of students in each of the nonsaturated Add Health schools has probably caused us to fail to identify some local positions, with the members of unidentified local positions wrongly assigned to local positions we did identify. We hope that sampling limitations will have minimal effect on overall parameter estimates averaged across local positions, but more information on each local position would be ideal.

Beyond responding to these limitations, future research in this area should also follow up on some of the intriguing patterns identified by this study. For example, we have not fully explored the potential dynamic between local position membership and educational outcomes, more broadly defined. Although we have established a connection between local positions and math coursetaking, we recognize that achievement also influences future course enrollment opportunities that, in turn, may shape the emergence and composition of local positions. Understanding this process could yield important information about how social milieus facilitate the linkage between micro and macro processes within schools and educational outcomes more generally.

While the effects of local positions are confined to math coursetaking in this study, local positions tap a general form of social organization generated by the dynamic interplay between individual agency and a social institution (e.g., adolescents' choices among courses offered by their schools). This interplay may occur in other arenas, such as when citizens choose to affiliate with various civic organizations that exist in their community, when children (and parents) choose to participate in certain sports

offered by their local recreation centers, or when retailers choose to sell their goods in particular markets. In each case, structural positions can emerge when there is clustering induced by sets of people who choose similar experiences in which to participate.

When structural positions occur in a social setting, people may be influenced by others who are members of their positions, even in the absence of direct interaction. Key to generating the localized social experience are the focal experiences that attract people with similar interests, enhance opportunities for exposure and direct interaction, and provide a basis for in- versus out-group distinctions. Each of these structural aspects defines a pool of potential friends that facilitates group processes and effects such as norms and reference, the confluence of which can generate cultural milieus that have effects beyond those of dyadic relationships.

While the social processes and their effects on math coursetaking that we observed in this study may tap a general phenomenon that occurs when people come together within a social structure, some unique features of our case are worth noting. As Coleman (1995) remarks, the high school is a setting with well-defined boundaries that brings together like individuals over an extended period to engage in structured activity. These attributes have facilitated the measurement of the subcontexts, or local positions, within the school. To be sure, structured formal activities also provide a setting in which social processes can emerge. Moreover, the school is a site of judgment and evaluation, the effects of which are probably accentuated by the adolescent life-course stage, which is susceptible to pressures to fit in. On the one hand, these aspects of our study have made it possible for us to estimate the effects of the local positions and tap the social milieus that they facilitate over the relatively short time period of one academic year. On the other hand, it is possible that these processes are characteristic of other social settings, such as work or religious or civic organizations. Regardless, adolescents' preparation for the transition to adulthood and the role of high schools in that process are of central importance to society.

In this study, we applied a new network algorithm to course transcript data to empirically characterize local positions as a mesolevel of social structure, between the individual and the school. We found that girls appear to take into account the norms of others in their local position when making decisions about math coursetaking and that this contributes to stratification of math attainment. Local positions thus capture a dynamic of schools that structures opportunities, the social implications of those opportunities, and, importantly, how the choices that adolescents make within this structure contribute to normative social contexts.

APPENDIX A

Construction of Measures

Dependent Variable

Advancement in math.—Constructed using Classification of Secondary School Courses (CSSC) codes, which are attached to each course on a transcript and specify the general subject and specific course title (e.g., Algebra I). Using this detailed coding scheme, ordinal indicators of course sequences were developed for the major course subjects within math (Riegle-Crumb et al. 2005). The categories of this sequence include (0) no math, (1) Basic/Remedial Math, (2) General or Applied Math, (3) Pre-algebra, (4) Algebra I, (5) Geometry, (6) Algebra II, (7) Advanced Math (Algebra III, Finite Math, Statistics), (8) Precalculus (including Trigonometry), and (9) Calculus. These categories reflect a hierarchy of courses ranging from less to more advanced. Note that students do not have to pass through each category of the sequence. For instance, students might take either advanced math or Precalculus but not both. Additionally, although most students' coursetaking patterns reflect a linear movement through the sequence, a minority of students may have different patterns. For example, in a subset of schools, some students went from Algebra II in 1994–95 to Geometry in 1995–96, although the latter is below the former in the sequence because the typical progression is in the opposite direction. These students (approximately 97, accounting for the transcript weights) were considered to have advanced. (This measure corresponds to the variables EAMSQ1–6 and EAMSQH in AHAA.)

Independent Variables

Human Capital

College aspirations.—On a scale of 1 to 5, where 1 is low and 5 is high, how much do you want to go to college? (This measure corresponds to the variable H1EE1 in Add Health.)

Parents' disappointment over no college.—On a scale of 1 to 3, where $1 =$ very disappointed and $3 =$ not disappointed, how disappointed would you be if your child did not graduate from college? (PC31 in Add Health)

Level of math in 1994–95.—Constructed using the same classification scheme as for our dependent variable. For this variable, too, we corrected for students in schools with unusual course sequences (e.g., by assigning Algebra II a value of 6 and Geometry a value of 7 in schools where it was normative to take Algebra II before Geometry).

Social Context

Mean math level of coursemates weighted by extent of overlap with each coursemate.—To account for exposure to others through dyadic course overlap, we developed the following network effects measure (Marsden and Friedkin 1994; Muller et al. 2007*b*). Define *course overlap$_{ii'}$* to represent the expected exposure of adolescent i to adolescent i' through coursetaking. Then, the exposure of i to the level of math in 1994–95 of i' through course overlap is defined as

$$\text{course overlap}_{ii'} \times \text{level of math in 1994–95}_{i'}.$$

Note that we weighted course overlap by the size of the course to reflect the expected exposure between two adolescents in the same course (see app. B). Note also that we use math courses taken in 1994–95 to model advancement between 1994–95 and 1995–96, to avoid concerns about endogeneity (i.e., having the same behaviors on the right- and left-hand sides of the model), or circularity, in estimation and interpretation (Marsden and Friedkin 1994; Muller et al. 2007*b*).

Mean math level of coursemates can then be defined as the mean exposure across all coursemates:

Mean math level of coursemates$_i$

$$= \frac{\Sigma_{i'}\ \text{course overlap}_{ii'} \times \text{level of math in 1994–95}_{i'}}{n_i},$$

where n_i represents the number of others with whom i has nonzero overlap, and level of math is centered around the grand mean to reduce collinearity.[19] Note also that we standardized course overlap$_{ii}'$ to have mean and standard deviation of 1 across the entire sample, to preserve the metric of math level.

We also constructed measures for exposure to mean math level of friends similar to that of exposure to others through coursetaking. In particular, we replaced course overlap$_{ii'}$ with *friend$_{ii'}$*, indicating whether adolescent i nominated i' as a friend or i' nominated i at wave 1, where wave 1 includes the Add Health In-School Survey as well as the In-Home wave 1. We assumed symmetric relationships to reduce the amount of sparse and missing data.

[19] We weighted the alters, i', using the Add Health wave 3 sampling weights to reflect differences in their probabilities of being in the sample.

Prior Educational Experiences

Ever been retained.—Have you ever repeated a grade or been held back a grade? (H1ED5 in Add Health)

Math grades for 1994–95.—Range is 0–4. See Riegle-Crumb et al. (2005). (EAMGPA1-EAMGPA6 in AHAA)

Grade level in fall of 1994.—Students' grade level in the 1994–95 school year (the year of the In-School Survey of Add Health). Because each course a student took in a given year is assigned a grade level on her transcript, this variable was calculated as the mean grade level of all courses taken in that year. For most students, all of the courses taken in a given school year had the same grade level, giving them a whole number for grade level. Some students, however, took courses marked with multiple grade levels in a single school year, and so they do not have a whole number value for grade level. The overall range is from 9 to 12, although for our analyses we included only those between 8.5 and 10.5. (ELGLV945 in AHAA)

Background

Ethnic category (from H1GI6A to H1GI6E [race] as well as H1GI4 [Hispanic ethnicity] in Add Health)

Parental education.—Mean of mother's education (H1RM1 in Add Health) and father's education (H1RF1), where 0 = less than eight years, 1 = eight or more years but did not complete high school, 2 = vocational training but not high school, 3 = high school, 4 = vocational post–high school, 5 = college but did not graduate, 6 = college, and 7 = more than college. For our final models this was dichotomized, with values below 5 coded 0 and values of 5 or above coded 1.

Controls Not in Final Models

PVT score.—Abbreviated Peabody Picture Vocabulary test score (AH_PVT in Add Health)

Family structure.—Coded 1 if two-parent family, 0 otherwise (famst5 in Add Health)

Working for pay.—How many hours working for pay do you spend in a typical nonsummer week? (H1EE4 in Add Health)

Sense of belonging in school.—A composite of three questions: Do you feel close to people at your school (H1ED19 in Add Health)? Do you feel like you are part of your school (H1ED20)? Are you happy to be at your school (H1ED22)? (Moody and Bearman 1997; cf. Goodenow 1993) Range is from 0 (strongly disagree) to 5 (strongly agree) and $\alpha = .78$.

APPENDIX B

Identifying Local Positions

To identify local positions from the transcript data, Field et al. (2006) developed a clustering algorithm that adapts Frank's (1995) clustering technique for one-mode network data (e.g., who talks to whom) to two-mode data (e.g., who takes which courses). Define θ_1 from the following model for the logit of x_{ij}, an indicator of whether student i took course j:

$$\log\left[\frac{p(x_{ij} = 1)}{1 - p(x_{ij} = 1)}\right] = \theta_0 + \theta_1 \text{ same local position}_{ij},$$

where *same local position*$_{ij}$ takes a value of 1 if student i and course j are in the same local position and is 0 otherwise. Thus, θ_1 directly and parsimoniously represents the fundamental basis for a local position; when θ_1 is large, coursetaking is concentrated within local positions and members of a local position should be exposed to one another through common courses.

Using the adapation in Field et al. (2006) of Frank's (1995) KliqueFinder algorithm to maximize θ_1 has three practical advantages for identifying local positions in each Add Health school. First, θ_1 represents a tendency but not an absolute criterion. As a result, variation in the data need not be accommodated by constructing overlapping positions—the algorithm identifies nonoverlapping positions, as is consistent with other conceptualizations of the social organization of schools in terms of tracks or categories.

Second, drawing on Breiger's (1974, 1991) insights into the duality of two-mode data, when θ_1 is large, students who are members of the same local position will participate in common courses (see the discussion in Field et al. [2006] of Skvoretz and Faust's [1999] adaptation of p* network models to two-mode data). Through this common participation, students will have the chance to interact with and be exposed to other members of their local position.

Third, the algorithm dynamically identifies the number of positions "on the fly"; therefore, researchers need not specify the number of positions a priori, nor must they interpret and choose among multiple clustering solutions according to subjective criteria. Thus, we were able to apply the algorithm objectively and consistently across the 78 Add Health schools that had adequate transcript data for study.

To account for courses of different sizes, we weighted the data under the assumption that interaction and exposure would likely have been

reduced in those courses with the highest rates of participation. In particular,

expected exposure

$$= \frac{\text{\# of Carnegie units for which a student took a given course}}{\text{\# of classes per course}}.$$

Here, number of classes per course was calculated by dividing the number of people who took a course (estimated from the AHAA data, given the sampling rate and the size of the school) by 30 (representing an average class size).[20] For example, a student would have a probability of $\frac{1}{2}$ of being exposed to another student in a course with 60 students. We then factored in the Carnegie units to reflect the duration of a student's participation in a course (one Carnegie unit represents roughly one hour per school day). If a student took a course of size 60 for one Carnegie unit, the expected exposure would be $\frac{1}{2}$, whereas, if the student took the same course for three Carnegie units, the expected unit of exposure would equal $\frac{3}{2}$, indicating a $\frac{1}{2}$ probability of interacting with any given other in the course for approximately three hours per day.

The transformation to expected exposure effectively applies weights to the indicators of which courses a student took. Following Frank (1996), these weights can be included in the calculation of θ_1, assuming the weights are measured on a ratio scale, which is consistent with our definition of expected unit of exposure (i.e., a weight of 2 is twice more than a weight of 1).

We applied Field and colleagues' clustering algorithm to each of the 78 high schools in AHAA that had more than 20 valid transcripts, to identify local positions. Originally, we included students in grades 9–12 in 1994–95 who were representative of the school (when transcript weights were applied). Because some schools, however, had fewer than 70 students in 1994–95, they provided few data from which to identify local positions with more specificity than merely broad tracks and grades. Consequently, we supplemented with transcripts for the same students from 1995–96 (because they were the same students, the 1995–96 sample did not include those who graduated before 1995–96 or who entered the school in 1995–96). Many students, therefore, provided two years of information, for 1994–95 and for 1995–96. Although this might violate a statistical as-

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[20] The National Center for Education Statistics (1998) reports that the average class size for secondary schools in 1993–94 was approximately 24, but this includes only teachers in departmental courses, which tend to be smaller than general courses that might appear on a transcript, such as physical education and driver's education. Even if our estimate of class size of 30 is variable, our measure still weights small courses more heavily to reflect the likely rates of interaction.

sumption of independence, our goal here was to identify local positions, not make statistical inferences, and we judged the transcript from a twelfth-grader in 1995–96 to be sufficiently informative beyond what is known about the same student in grade 11 in 1994–95 to warrant inclusion. An important implication of our decision is that we are essentially assuming that the courses defining local positions were relatively stable from 1994–95 to 1995–96. Given the stability of course offerings and master schedules (Delany 1991), we believe this to be a reasonable assumption.

One result of the algorithm is that some local positions contained only one or two students. Because some of our theoretical mechanisms draw from the triad, we reassigned the approximately 2,040 students in local positions smaller than three to new local positions if they had a classification probability of greater than .10 to be assigned to the new local positions. See Vermunt and Magidson (2000) for calculation of classification probabilities. Approximately 406 students could not be assigned to a new local position with more than one member and so were left as single members of their own local positions. Ultimately, we identified 1,173 local positions across 78 schools, with the typical position containing almost 10 AHAA students.

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