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The Effects of Student–Faculty Interaction on Academic Self-Concept: Does Academic Major Matter?

Young K. Kim · Linda J. Sax

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Abstract Using cross-classified multilevel modeling, this study attempted to improve our understanding of the group-level conditional effects of student–faculty interaction by examining the function of academic majors in explaining the effects of student–faculty interaction on students' academic self-concept. The study utilized data on 11,202 undergraduate students who completed both the 2003 Freshman Survey and the 2007 College Senior Survey at 95 baccalaureate institutions nationwide. The results show that the strength of the relationship between having been a guest in a professor's home and students' academic self-concept varies by academic major. Findings also suggest that some aspects of departmental climate, such as a racially more diverse student body and greater faculty accessibility, can possibly magnify the beneficial effects of student–faculty interaction. The study discusses the theoretical and practical implications of the findings.

Keywords Student–faculty interaction · Academic self-concept · Academic majors · Conditional effects · Multilevel modeling

Introduction

Higher education scholars have established key concepts associated with college students' development, and interaction with faculty is perhaps the most frequently cited institutional

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Y. K. Kim (✉)
Department of Doctoral Higher Education, Azusa Pacific University, Azusa, CA 91702, USA
e-mail: ykkim@apu.edu

L. J. Sax
Higher Education and Organizational Change, Graduate School of Education & Information Studies, University of California, Los Angeles, CA, USA

practice thought to improve student outcomes. Astin (1984) suggests in his involvement theory that a student's level of involvement in educationally meaningful college experiences substantively shapes his or her learning and development in college. Specifically, Astin (1993) argues that frequent interaction between students and faculty is one of the most favorable forms of student involvement and is more strongly linked to college satisfaction than any other student background or institutional characteristic. Tinto (1987, 1993) also suggests in his theory of student departure that student–faculty interaction—both formal interaction in the classroom and informal interaction outside of class—plays a pivotal role in students' persistence by facilitating their greater integration in academic and social systems of institutions. Similarly, in his model of undergraduate socialization, Weidman (1989) emphasizes the contribution of the socialization process in general, and student–faculty interaction in particular, to the development of college student outcomes. There is also ample empirical evidence of the relationship between student–faculty interaction and college student outcomes, including academic achievement, intellectual/academic development, persistence, and academic satisfaction (e.g., Astin 1977, 1993; Dika 2012; Endo & Harpel 1982; Kim 2010; Kim et al. 2009; Kim & Sax 2009, 2011; Kuh 1995; Kuh & Hu 2001; Lundberg & Schreiner 2004; Sax et al. 2005; Pascarella 1980, 1985; Pascarella & Terenzini 1976, 1991, 2005; Strauss & Terenzini 2007; Thompson 2001).

While the existing research has supported the widespread belief that student–faculty interactions are important to college students' learning and development, these studies tend to focus on academic or cognitive college outcomes as the byproducts of student–faculty interaction, relatively ignoring the examination of the relationship between faculty interaction and psychosocial college student outcomes such as students' self-concepts, values, attitudes, or beliefs. Another gap in the research on student–faculty interaction in particular, and college impact research in general, is the investigation of *group*-level conditional effects. Specifically, studies in the past decade have found that the effect of the same intervention or experience on student outcomes might be different (i.e., conditional) across student subgroups (Anaya & Cole 2001; Colbeck et al. 2001; Cole 2004; Kezar & Moriarty 2000; Kim & Sax 2009; Lundberg & Schreiner 2004; Mayo et al. 1995; Sax et al. 2005, 2008). However, these studies are mostly interested in examining *individual*- (or student-) level conditional effects by disaggregating student subsamples by race, gender, or other student demographic/background characteristics, and they are less interested in investigating *group*-level conditional effects (e.g., disaggregated by institutional sub-environments such as academic majors, departments, or disciplines).

In this study, we attempt to add to the research on student–faculty interaction by examining the effect of student–faculty interaction on academic self-concept, a psychosocial college outcome, and how the effect varies by students' academic major. Academic self-concept is among the most desired psychosocial college student outcomes given its potential positive effect on academic achievement (Cokley 2000a; Graham 1994; Stipek 2002), and it has been considered one of the key byproducts of student–faculty interaction by some recent studies (Berger & Milem 2000a; Bjorkland et al. 2002; Cole 2007, 2008; Komarraju et al. 2010). Using cross-classified multilevel modeling, this study addresses the following three research questions: (1) Are there differences in the nature of, time allocated to, and satisfaction with, student–faculty interaction across different academic majors? (2) Are the effects of student–faculty interaction on academic self-concept different for students across academic majors? (3) If so, what departmental characteristics and conditions contribute to disciplinary differences in the effects of student–faculty interaction on academic self-concept?

Literature Review

Influence of Student–faculty Interaction

Myriad college impact studies have documented positive relationships between student–faculty interaction and a broad range of student outcomes (see Pascarella 1980; Pascarella & Terenzini 1991, 2005 for an extensive review). Previous research has indicated that student–faculty interaction improves college students' grade point average (GPA) (Anaya & Cole 2001; Dika 2012; Kim 2010; Kim & Sax 2009), increases persistence (Hernandez 2000; Lau 2003; Pascarella & Terenzini 1977; Spady 1970, 1971; Tinto 1975), facilitates intellectual/cognitive skill development (Bean 1980; Endo & Harpel 1982; Kim & Sax 2011; Pascarella & Terenzini 1976, 1977, 1978, 1979; Terenzini & Pascarella 1977, 1978, 1980; Volkwein et al. 1986), and encourages students' learning (Lundberg & Schreiner 2004) and vocational preparation (Kuh & Hu 2001). Positive college outcomes related to student–faculty interaction also include several affective or psychosocial outcomes such as educational aspirations (Kim 2010; Kim & Sax 2009), satisfaction (Kuh & Hu 2001), racial tolerance (Kim 2010), and academic or intellectual self-concept (Clark et al. 2002; Cokley 2000b; Cole 2007, 2011).

Researchers have attributed at least part of the association between student–faculty interaction and college outcomes to the undergraduate socialization process (Pascarella 1980; Pascarella & Terenzini 1991, 2005; Tinto 1987, 1993). Because faculty members are key agents of socialization in the college environment, students' interpersonal interactions with faculty may influence their learning and development during the college years through, for instance, the shared values between faculty and students towards better performance, greater accessibility to faculty, and enhanced faculty support. In a methodological sense, the effect of student–faculty interaction on student outcomes has been considered indirect, being mediated by greater student involvement in other meaningful institutional practices. That is, interactions between students and faculty are believed to facilitate greater levels of engagement in other desired college experiences, which in turn leads students to move towards favorable academic and personal development (Pascarella & Terenzini 1991, 2005; Tinto 1993; Twale & Sanders 1999). However, some studies have also argued that the relationship between student–faculty interaction and college outcomes seems bidirectional (reciprocal) rather than unidirectional, suggesting that higher levels of faculty interaction improve student outcomes, and the enhanced outcomes facilitate more faculty interactions (Kim 2010; Pascarella & Terenzini 1991, 2005; Terenzini et al. 1996).

College Students' Academic Self-Concept

Among other self-concepts (e.g., general, social, emotional, or physical), academic self-concept refers to one's perceptions about himself or herself regarding academic capacity (Byrne 1984; Lent et al. 1997; Shavelson & Bolus 1982; Wigfield & Karpathian 1991). Academic self-concept has received much attention from academics and education professionals (both K-12 and higher education) given its potential impact on students' academic achievement. A number of studies have underscored the positive relationship between academic self-concept and achievement among school-age children and college students (Graham 1994; Marsh 1992; Marsh & Yeung 1997; Shavelson & Bolus 1982; Skaalvik & Hagtvet 1990; Stipek 2002). In particular, some studies have documented the impact of academic self-concept (self-efficacy in some cases) on college students'

academic achievement including cumulative GPA, term grade, course grade, and math performance (Choi 2005; Lent et al. 1997; Pajares & Miller 1994; Wood & Locke 1987).

The literature suggests that students' academic self-concept generally grows during the college years (Astin 1993; Hesse-Biber & Marino 1991) and several college experiences—mostly interactions with peers and faculty members—contribute to the development of academic self-concept. Studies show that various forms of peer interactions including socializing with friends, tutoring other students, discussing course content with other students, and participating in student activities improves students' academic self-concept (Astin 1993; Berger 2000; Sax 1994a, b; Szelenyi 2002). The impact of peer engagement on academic self-concept seems to be more pronounced when such interaction involves a meaningful cross-racial interaction among students (Chang, 1999, 2001; Gurin 1999).

Student–faculty interaction is considered another vital predictor of academic self-concept. The literature suggests that students' interaction with faculty—whether inside or outside the classroom, or whether related to research, courses, or other contexts—significantly contributes to improvement in their academic self-concept (Astin 1993; Berger & Milem 2000a; Cokley 2000a; Cole 2007, 2011; Szelenyi 2002). While student–faculty interaction tends to be generally associated with positive academic sense of self among college students, it is not always the case, and it depends on the nature of the interaction. For example, Cole (2007) found that receiving advice or critique from faculty reduced college students' intellectual self-concept while other types of faculty contact, such as course-related faculty interaction and faculty mentorship, improved college students' intellectual self-concept. Similarly, Komarraju et al. (2010) showed that having negative experiences with faculty predicted declines in students' academic self-concept whereas other aspects of student–faculty interaction (e.g., interactions outside of class, connecters, accessibility) were positively related to academic self-concept.

The aforementioned literature review informs us that there is ample research on the impact of student–faculty interaction. However, little research exists on conditional effects of student–faculty interaction on college outcomes—particularly, psychosocial outcomes. Specifically, contrary to a *general* college effect, a *conditional* effect assumes that the same intervention or experience might not have the same impact for all kinds of students (Pascarella 2006). Some studies demonstrate that the impact of student–faculty interaction may differ by student gender (Colbeck et al. 2001; Kezar & Moriarty 2000; Kim & Sax 2009; Sax 2008; Sax et al. 2005), and others reveal differences by race (Cole 2004; Kim 2010; Kim & Sax 2009; Lundberg & Schreiner 2004; Mayo et al. 1995). Literature on academic sub-environments suggests that we may also expand our investigation of conditional effects by examining such differential effects across academic disciplines or majors. Using Holland's (1985, 1997) theory of careers as their framework, Smart et al. (2000) and other studies argue that understanding different academic disciplines and their environments is essential to explaining college students' experiences and their development in college (Feldman et al. 2001, 2004; Milem & Umbach 2003; Wolniak & Pascarella 2005). Still, these studies tend to investigate the disciplinary variation in college experiences or congruence between students and environments, relatively ignoring the examination of conditional effects of such college experiences on student outcomes across different academic sub-environments. Thus, despite the fact that students tend to interact with faculty in the context of particular majors, departments, or academic disciplines, we have only a limited understanding of how the impact of student–faculty interactions might vary across academic fields.

This study attempts to improve our understanding of the disciplinary effects of college by examining how the effects of student–faculty interaction on students' senior-year

academic self-concept vary by academic major. It is also important to acknowledge that the effect of student–faculty interaction may be conditioned by the *type* of student–faculty interaction. As we learned in our literature review, some types of student–faculty interaction seems to negatively affect college student outcomes, while others predict improved college outcomes (Cole 2007; Komarraju et al. 2010). Consequently, this study uses six different student–faculty interaction measures to capture the role played by the type of faculty interaction, as well as the academic discipline, on the effect of student–faculty interaction.

Conceptual Framework

The conceptual frameworks for this study include Holland's (1973, 1997, 1985) theory of careers, Astin's (1984) involvement theory and Input-Environment-Output (I-E-O) model (1991), and Weidman's (1989) model of undergraduate socialization. As a person-environment fit theory, Holland's theory hypothesizes that the interaction or congruence between individuals and their environments shapes their behaviors. Particularly, in the context of higher education, Holland's theory argues that the fit or interaction between college students and their majors might affect their college experiences and outcomes. Holland describes six different personality types that both contribute to and are reinforced by individual disciplines (i.e., environments). These types are: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional. Based on Holland's theory, this study assumes that structural and contextual environments of different academic majors reflect these different "types" and uniquely shape the pattern and effect of student–faculty interaction within each academic major. Indeed, there exists a number of higher education studies that use Holland's theory as a framework, and the studies generally support the validity of Holland's theory by demonstrating a significant relationship between students' academic majors and their college experiences and outcomes (e.g., Feldman et al. 2001, 2004; Milem & Umbach 2003; Smart et al. 2000; Umbach 2006; Umbach & Milem 2004; Wolniak & Pascarella 2005).

Another conceptual framework that guides this study is Astin's (1984) involvement theory. Astin's concept of involvement refers to the amount of physical and psychological investments that students devote to desirable college experiences. He suggests that greater student investment in meaningful college experiences (such as interacting with faculty) yields more favorable outcomes. The involvement concept enables us to consider the aspects of students' academic engagement as well as considering the role played by academic majors when we examine the effects of student–faculty interaction. Given that Astin's (1984) involvement theory guides our understanding of student engagement, his I-E-O (Inputs-Environments-Outcomes) model (1991) is also adopted to guide our analyses. The I-E-O model stresses the importance of modeling groups of variables in temporal order (first inputs and then environments), which allows us to assess a less biased estimate of the unique effects of different college experiences on student outcomes.

Also relevant to this study is Weidman's (1989) model of undergraduate socialization. While Weidman's model is similar to other traditional college impact models in that it acknowledges the effects of students' pre-college characteristics and college experiences on college outcomes, his model is more explicit in addressing the role of student–faculty interaction in the prediction of students' psychosocial outcomes such as self-concepts, values, goals, and aspirations. Emphasizing the sociological nature of college impact, Weidman argues that students both influence and are influenced by college environments

through their interactions with socializing agents (e.g., faculty, peers, and staff) and their exposure to the normative context such as departmental and institutional climate.

Method

Data Source and Sample

This study used data from the 2003 Freshman Survey (TFS) and the 2007 College Senior Survey (CSS) of the Cooperative Institutional Research Program (CIRP). The CIRP is a national longitudinal study of American higher education administered by the Higher Education Research Institute (HERI) at the University of California, Los Angeles. As a pretest for a longitudinal assessment of college impact on students, the 2003 TFS was administered to full-time, first-year entering students at the beginning of the freshman year to collect information before students were exposed to substantial college experiences. This survey included student background information and pre-college characteristics. The 2007 CSS was administered to the same students at the end of their fourth college year. This follow-up survey included post-test questions paralleling items in the 2003 SIF as well as information regarding student college experiences and outcomes including undergraduate academic performance, student–faculty interaction, peer interaction, extracurricular activities, and diversity engagement. A total of 392,937 students at 649 institutions responded to the 2003 TFS, while 29,968 students at 109 institutions responded to the 2007 CSS.[1] Consequently, the full longitudinal dataset included 14,450 students at 95 institutions.

For this study, the sample was restricted to 14,450 undergraduate students who completed both the 2003 TFS and the 2007 CSS at 95 baccalaureate institutions. Given biases in institutional participation in the TFS and CSS, the sample overrepresents students at private liberal arts colleges. This institutional bias is also reflected in the disciplines represented in the sample. Namely, while Holland (Rosen et al. 1989) classified academic majors into six academic disciplines, this study used four of them (Artistic, Social, Investigative, and Enterprising) given that Realistic and Conventional were severely underrepresented in the sample (see Appendix Table 5 for details on academic majors of CIRP data classified by Holland's academic environments). Students who did not declare their majors at the time of survey administration were also excluded from the analysis. Furthermore, to improve the reliability of department-level variables in multilevel modeling, academic majors that had fewer than 100 respondents nationwide were excluded from the study sample. In addition, the data were screened and cleaned to meet multilevel modeling assumptions, and the amount and patterns of missing values were examined using the Missing Values Analysis (MVA) module of SPSS 20.0. Results of the missing data analysis indicated that no variable in our dataset had more than 2.7% of missing values and there were not any systematic patterns among missing values; hence, all missing data were imputed using Expectation-Maximization (EM) algorithms as suggested by Tabachnick and Fidell (2007).

[1] Because schools vary in how they administer the TFS and CSS, and do not report on their target population, it is not possible to calculate a formal "response rate" to either survey. Further, the CSS includes only a subset of institutions that participated in the TFS, and may include institutions that did not participate in the TFS; thus, the matched samples of TFS 2003 and CSS 2007 students was created from the subset of institutions that chose to participate in both surveys.

Consequently, the final analytical sample of this study was composed of 11,202 students who were cross-classified by both 30 academic majors and 95 institutions. The sample included 63.2 % female students and 36.8 % male students. The racial composition of the final sample was: 81.0 % White, 3.0 % African American, 5.4 % Asian American, 4.0 % Latino, and 6.7 % other races. When we grouped students based on four of six academic disciplines proposed by Holland (Rosen et al. 1989), 17.0 % came from Artistic, 38.6 % from Social, 22.8 % from Investigative, and 21.6 % from Enterprising. Finally, the sample was composed of about two-thirds students from four-year colleges (67.8 %) and one-third from universities (32.2 %); in addition, 95.7 % of students attended private institutions, with only 4.3 % attending public institutions.

Variables

While this study is mainly interested in examining the disciplinary variation in the effects of student–faculty interaction on college students' academic self-concept (i.e., how the effects are different across academic majors/departments), we employed a cross-classified multilevel model for data analysis, specifying both department- and institution-level as higher levels of clusters of individual students (further discussion on cross-classified model is provided in the "Methods" section). This analytic approach allowed us to not only adequately address the nature of the CIRP sampling procedures (i.e., cluster sampling by institutions) but also to test the possible institution-level variability in the effect of student–faculty interactions. Based on the three-level cross-classified (or cross-nested) hierarchy in the CIRP data, this study utilized student-level, department- (major-), and institution-level variables.

Student-Level Variables

Student-level variables included one dependent variable (a factor scale of academic self-concept), six primary independent variables (student–faculty interaction measures), and 10 student-level control variables (see Appendix Table 6). Academic self-concept, our dependent variable, is a composite measure and consists of three items that assess students' self-ratings on academic and writing ability and intellectual self-confidence in their fourth college year ($\alpha = .70$). This composite measure was generated through an exploratory factor analysis using principal component factoring and Varimax rotation methods. Table 1 presents the factor loadings and reliability estimates of the academic self-concept factor and its individual items across different academic disciplines as well as for the

Table 1 Factor loadings and reliability estimates of academic self-concept items across different academic disciplines

	Artistic ($n = 1,905$)	Social ($n = 4,320$)	Investigative ($n = 2,558$)	Enterprising ($n = 2,419$)	Full Sample ($n = 11,202$)
Factor loading					
Self-concept on academic ability	.82	.83	.81	.81	.82
Intellectual self-confidence	.79	.83	.79	.77	.78
Self-concept on writing ability	.74	.79	.72	.73	.77
Cronbach's alpha	.68	.75	.66	.66	.70

aggregate sample. The results showed that both factor loadings and reliability estimates were well within the acceptable range (λ ranges from .72 to .83; α ranges from .66 to .75).

This study used six student–faculty interaction measures to capture variations in the type of faculty interaction. The first is a nine-item factor scale that assesses faculty mentorship, including items such as encouragement to pursue graduate study, opportunities to work on a research project, and emotional support and encouragement. This scale is a CIRP construct created by HERI using item response theory (IRT) (see Appendix Table 6, Sharkness and DeAngelo (2011), and Sharkness et al. (2010) for additional details on this construct). The remaining student–faculty interaction measures include two individual items that gauge students' time devoted to faculty contact (talking with faculty either *during* or *outside of* office hours), and three individual items that capture the nature of faculty interaction (being a guest in a professor's home, asking a professor for advice outside of class, and challenging a professor's ideas in class). Utilizing the multiple student–faculty interaction measures, we attempted to obtain a more nuanced understanding of the nature of student–faculty interaction. We expected that the composite measure of faculty mentorship allowed us to examine the quality of relationships between faculty and students, while the five individual items captured the frequency and type of faculty interaction. While we were mainly interested in the above six student–faculty interaction measures in the relationship to academic self-concept, some descriptive analyses employed two additional satisfaction measures: satisfaction with the amount of faculty contact, and satisfaction with the ability to find faculty/staff mentor.

Student-level control variables were selected based on the literature on student–faculty interaction discussed earlier, with further backing from research on academic self-concept. Based on Astin's I-E-O model (1991), the control variables were organized in temporal order as follows: (1) student demographic and background characteristics, (2) pretest, and (3) college experiences. Student demographic and background characteristics included gender, race, and high school GPA, while the pretest measure is a three-item factor scale representing students' self-assessment of their academic self-concept when they *entered* the college in the same three areas as the dependent variable: academic ability, writing ability, and intellectual self-confidence (Chronbach's alpha = .63). College experiences included variables thought to be associated with students' academic self-concept development, such as cross-racial interaction, working on campus, studying or doing homework, attending classes or labs, studying with other students, and socializing with friends.

Department-Level Variables

Department-level variables were included in multilevel modeling of this study to model group-level (i.e., academic major- or department- level) effects. These variables include disciplinary typology variables, department demographic variables (e.g., % female students), and department climate variables (e.g., average satisfaction with faculty accessibility) to represent each academic major's structural and cultural characteristics (see Appendix Table 6). Disciplinary typology variables are broader categories of academic majors, and this study used four of Holland's (1985) six clusters of academic majors: Artistic, Social (reference), Investigative, and Enterprising. While department demographic variables included departmental proportions of female and racial minority students, department climate variables included departmental average degree of satisfaction with the amount of faculty contact and satisfaction with faculty accessibility. Informed by both Weidman's (1989) concept of departmental normative context and previous studies on college peer group effect (e.g., Astin 1993; Dey 1996, 1997; Feldman & Newcomb 1969;

Milem 1994, 1998; Pascarella et al. 1996; Pascarella & Terenzini 1991, 2005; Sax 1996), the department climate variables were chosen in this study to examine how departments' peer normative context possibly affects college experiences at the student level (student–faculty interaction in this case).

Institution-Level Variables

Institutional-level variables used in this study include both institutional characteristic and institutional environment variables. Institutional characteristic variables assess structural or organizational features of institutions, and this study utilized four institutional characteristic variables: institutional type, control, size, and selectivity. Whereas college impact literature generally suggests that the net effects of these institutional characteristics on student outcomes (i.e., *between*-institution effects) tend to be relatively trivial compared to those of academic sub-environments (e.g., majors, departments, or academic disciplines) *within* institutions (Feldman & Newcomb 1969; Feldman et al. 2008; Jessor 1981; Laird et al. 2008; Pascarella & Terenzini 2005; Umbach & Wawrzynski 2005), some studies did identify a statistically significant net effects of some institutional characteristics on college students' psychosocial outcomes including academic self-concept (Astin 1993; Pascarella et al. 1996; Pierson et al. 2003; Sax 1994a, b). In contrast, institutional environment variables capture organizational cultures of institutions, and this study used institutional percentage of students of color to measure campus culture of diversity. Organizational cultures in general, campus structural diversity in particular, were found in previous studies to significantly affect students' academic self-concept and other outcomes (Berger 2002; Berger & Milem 2000b; Chang 1996, 1999; Smart & Hamm 1993). Correlation matrices for variables used in this study are available from the first author upon request.

Analysis

Statistical analyses used in this study include cross-tabulations, χ^2 tests of independence, and cross-classified multilevel modeling. First, to answer our first research question, cross-tabulations with χ^2 tests were conducted using SPSS 20.0. We compared the nature of, time allocated to, and satisfaction with student–faculty interaction among different academic disciplines. Then, we formulated and tested a series of cross-classified multilevel models using HLM 6.08 to examine *whether* and *why* the strength of association between student–faculty interaction and academic self-concept varies across academic majors, considering the possible institution-level variability. Cross-classified multilevel modeling is an extension of linear mixed modeling (LMM), including hierarchical linear modeling (HLM) and multilevel modeling, and allows researchers to handle the data that are not completely hierarchical (Raudenbush & Bryk 2002; Garson 2013). While the general assumption of HLM is complete nesting (i.e., each lower-level unit belongs to one and only one higher-level unit), cross-classified data do not meet the nesting assumption. In our case, a particular academic major can be observed in multiple institutions, which makes students cross-nested or cross-classified by both departments and institutions. Specifically, to answer our second and third research questions, we tested the following three sets of cross-classified models: (1) unconditional model, (2) randomly varying effects model, and (3) full model explaining randomly varying effects.

Unconditional Model

The unconditional model was used in this study as a preliminary step to examine total variance in our outcome measure (i.e., academic self-concept) in terms of variation between academic majors, between institutions, and within major-by-institution cells. The model included no predictor variables at any level and can be represented using the following two equations.

Level-1 or within-cell model

$$Y_{ijk} = \pi_{0jk} + e_{ijk} \tag{1}$$

Level-2 or between-cell model

$$\pi_{0jk} = \theta_0 + b_{00j} + c_{00k} \tag{2}$$

At level-1 or within-cell model, the outcome for a student i in institution j and academic major k, Y_{ijk}, was predicted by a cell mean, π_{0jk}, (i.e., average of academic self-concept within each major-by-institution cell) and a random level-1 error, e_{ijk}. Then, the cell mean in the level-1 or within-cell model, π_{0jk}, became an outcome in the level-2 or between-cell model, and it was predicted by grand mean, θ_0, (i.e. aggregate mean of academic self-concept including all academic majors and institutions), random main effect of institution, b_{00j}, and random main effect of major, c_{00k}.

Randomly Varying Effects Model

We then considered an analysis of the relationship between student–faculty interaction and academic self-concept across 95 institutions and 30 academic majors of our study to investigate whether the relationship is *conditional (different)* by academic majors and/or institutions. Before specifying the final randomly varying effects model, we first estimated the model using all 16 student-level variables at level-1 or within-cell model, six of which were student–faculty interaction measures. This primary analysis showed that some parameter estimates of the level-1 variables were not statistically significant once other level-1 variables were controlled; hence, the corresponding variables (i.e., studying with other students, faculty mentorship, hours per week talking with faculty *during* office hours, and hours per week talking with faculty *outside of* office hours) were deleted from the level-1 equation, and a reduced model was specified as recommended by Raudenbush & Bryk (2002). The following equations (Eqs. 3, 4) display the final, reduced randomly varying effects model estimated in this study.

Level-1 or within-cell model

$$\begin{aligned} Y_{ijk} = {} & \pi_{0jk} + \pi_{1jk}(\text{Female}) + \pi_{2jk}(\text{Minority}) + \pi_{3jk}(\text{High School GPA}) + \pi_{4jk}(\text{Pretest}) \\ & + \pi_{5jk}(\text{Cross} - \text{racial interaction}) + \pi_{6jk}(\text{Working on campus}) \\ & + \pi_{7jk}(\text{Studying/Homework}) + \pi_{8jk}(\text{Attendingclasses/labs}) \\ & + \pi_{9jk}(\text{Socializing with friends}) + \pi_{10jk}(\text{Having been a guest in a professor's} \\ & \text{home}) + \pi_{11jk}(\text{Asking a professor for advice outside of class}) \\ & + \pi_{12jk}(\text{Challenging aprofessor's ideas in class}) + e_{ijk} \end{aligned} \tag{3}$$

In the level-1 model (see Eq. 3), each student's score on academic self-concept, Y_{ijk}, was characterized by 14 parameters: an intercept, π_{0jk}, 12 regression coefficients (slopes), π_{1jk} to π_{12jk}, and a random error, e_{ijk}. Of these parameters, three slopes of interest (i.e.,

slopes of three student–faculty interaction measures, π_{10jk} to π_{12jk}) were specified to vary across both institutions and academic majors in the level-2 model as a function of a base slope (grand average slope across institutions and academic majors), θ_{100} to θ_{120}, a random effect of institution (unique variance to the slope associated with institution j), b_{100j} to b_{120j}, and a random effect of academic major (unique variance to the slope associated with academic major k), c_{100k} to c_{120k} (see Eq. 4). By doing this, we could examine whether the relationship between student–faculty interaction and academic self-concept (i.e., slopes of student–faculty interaction measures) significantly varies across academic majors and/or institutions. In contrast, all other parameters (i.e., the intercept, π_{0jk}, and the slopes from π_{1jk} to π_{9jk}) were fixed across both institutions and academic majors, given that we were not interested in institutional or departmental variation in those parameters. In the randomly varying effects model, all level-1 variables were centered on the grand mean, except for dichotomous variables, for a more meaningful interpretation of results. With the grand mean centering, an intercept calculated by the models in this study can represent an adjusted mean for all institutions and academic majors.

Level-2 or between-cell model

$$\begin{aligned}
\pi_{0jk} &= \theta_{00} \\
\pi_{1jk} &= \theta_{10} \\
&\vdots \\
\pi_{9jk} &= \theta_{90} \\
\pi_{10jk} &= \theta_{100} + b_{100j} + c_{100k} \\
\pi_{11jk} &= \theta_{110} + b_{110j} + c_{110k} \\
\pi_{12jk} &= \theta_{120} + b_{120j} + c_{120k}
\end{aligned} \tag{4}$$

Full Model Explaining Randomly Varying Effects

Having estimated the possible institutional and/or departmental variability of the three model parameters of our interest (i.e., slopes of three student–faculty interaction measures) in the randomly varying effects model, we now attempt to develop an explanatory model to account for this variability. That is, we seek to understand *why* some academic majors have stronger or weaker association between student–faculty interaction and academic self-concept than other academic majors, accounting for possible institutional variability in the association. To answer this question, we specified a full model, the most elaborate cross-classified multilevel model of this study. In this model, the level-1 model remained the same as in the final, reduced randomly varying effects model (see Eq. 3). However, slopes of two student–faculty interaction measures—i.e., having been a guest in a professor's home (π_{10jk}) and challenging a professor's ideas in class (π_{12jk})—were conditioned by seven department-level variables and five institution-level variables, respectively, at level-2 (see Eq. 5). This was because the results of earlier analyses on the randomly varying effects model in this study showed that the slope of having been a guest in a professor's home significantly varied across academic majors (but not across institutions), while the slope of challenging a professor's ideas in class significantly varied across institutions (but not across academic majors). In contrast, the slope of another student–faculty interaction measure—asking a professor for advice outside of class (π_{11jk})—was specified as fixed across both institutions and academic majors because our results showed that the effect of this type of faculty interaction on academic self-concept significantly varied neither by academic majors nor by institutions.

Level-2 or between-cell model

$$
\begin{aligned}
\pi_{0jk} &= \theta_{00} \\
\pi_{1jk} &= \theta_{10} \\
&\vdots \\
\pi_{9jk} &= \theta_{90} \\
\pi_{10jk} &= \theta_{100} + \beta_{101}(\text{Artistic}) + \beta_{102}(\text{Investigative}) + \beta_{103}(\text{Enterprising}) + \beta_{104}(\%\text{Female}) \\
&\quad + \beta_{105}(\%\ \text{Minority}) + \beta_{106}(\text{AVG: Satisfaction with amount of contact}) + \beta_{107} \\
&\quad (\text{AVG: Satisfaction with faculty accessibility}) + c_{100k} \\
\pi_{11jk} &= \theta_{110} \\
\pi_{12jk} &= \theta_{120} + \beta_{121}(\text{Four - year college}) + \beta_{122}(\text{Private institution}) + \beta_{123}(\text{Selectivity}) \\
&\quad + \beta_{124}(\text{Undergraduate enrollment}) + \beta_{125}(\%\ \text{Minority}) + b_{120j}
\end{aligned}
\tag{5}
$$

Results

Patterns in Student–Faculty Interaction by Academic Disciplines

We first examined if the patterns of student–faculty interaction are different across academic disciplines by conducting multiple sets of cross-tabulations and χ^2 tests on a complete range of items that measure various aspects of student–faculty interaction—i.e., nature of, time allocated to, and satisfaction with faculty contact. The results in Table 2 show that the disciplinary differences in all aspects of student–faculty interaction were statistically significant. In terms of the nature of student–faculty interaction, the results indicate that students in Artistic fields (e.g., Arts, Language/Literature) tended to visit professors' homes as a guest, ask professors for advice outside of class, challenge professors' ideas in classes, and receive faculty mentoring more frequently than their peers in other fields. In contrast, students in Enterprising disciplines (e.g., Journalism, Business Administration, Finance) were less likely to be engaged in such experiences (except challenging professor's ideas) than their peers in other areas. When it comes to time allocation, students in Artistic fields tended to invest more hours in talking with faculty during or outside of office hours than their counterparts in other fields, while students in Enterprising fields tended to invest fewer hours in such communication with faculty. Students in Artistic majors were also more satisfied with both the amount of faculty contact and the accessibility of faculty/staff mentors than were students in other disciplines, whereas students in Enterprising majors were less satisfied with both items.

Estimation of Unconditional Model

To examine how much variation in students' academic self-concept exists between academic majors (departments), between institutions, and within major-by-institution cells, we estimated an unconditional model that has no predictor variable. Results show that the estimated variance of intercept for academic self-concept was statistically significant at both department-level ($\tau_{c00} = .02$, $\chi^2 = 570.58$, $p < .001$) and institution-level ($\tau_{b00} = .01$, $\chi^2 = 442.89$,

Table 2 Patterns in student–faculty interaction by academic disciplines

	Artistic (n = 1,905) Proportion	Social (n = 4,320) Proportion	Investigative (n = 2,558) Proportion	Enterprising (n = 2,419) Proportion	Significance test χ^2
Nature					
Have been a guest in a professor's home frequently	13.3	8.3	8.2	4.2	496.854*
Frequently asked a professor for advice outside of class	38.7	27.5	29.8	22.5	193.358*
Frequently challenged a professor's ideas in class	14.1	10.9	7.0	8.0	194.310*
Reported a high[a] level of faculty mentorship score	29.5	27.5	26.3	17.9	130.942*
Time allocation					
Spent one or more hours per week talking with faculty during office hours	45.2	40.5	43.3	34.3	85.314*
Spent one or more hours per week talking with faculty outside of class or office hours	37.3	29.6	34.1	25.7	162.533*
Satisfaction					
Satisfied[b] with amount of faculty contact	88.0	85.4	84.0	81.5	48.503*
Satisfied[b] with ability to find faculty/staff mentor	78.3	75.8	75.4	72.1	28.077*

[a] High level means upper quartile

[b] Satisfied = satisfied or very satisfied

* $p < .001$

$p < .001$), indicating that students' average academic self-concept significantly varies across different academic majors as well as institutions. When it comes to department-level variation in mean academic self-concept scores, our auxiliary descriptive analysis shows that Philosophy ($m = 4.36$), English Language and Literature ($m = 4.23$), and Political Science ($m = 4.17$) reported the highest departmental mean of academic self-concept scores among 30 academic majors used in this study, whereas Nursing ($m = 3.67$), Elementary Education ($m = 3.68$), and Communications ($m = 3.80$) reported the lowest mean academic self-concept scores. Using the formula suggested by Raudenbush & Bryk (2002), we also calculated the two *intra-unit correlations*, intra-major and intra-institution correlation, to determine the proportion of total variance in academic self-concept that was due to departmental and institutional differences. The results of this calculation indicate that 5.9% [$\rho = \tau_{c00}$ / ($\tau_{b00}+\tau_{c00}+\sigma^2$) = .02/(.01+.02+.31) = .059] of the variance in academic self-concept was due to differences among academic majors, while 2.9 % [$\rho = \tau_{b00}$/ ($\tau_{b00}+\tau_{c00}+\sigma^2$) = .01/ (.01+.02+.31) = .029] of it was due to differences among institutions.

Estimation of Randomly Varying Effects Model

Given the aforementioned finding that students' self-assessment of academic self-concept significantly varies by both academic major and institution, we then tested whether the

Table 3 Estimation of randomly varying effects model for academic self-concept

Fixed Effect	Coefficient	SE	*T* ratio	df
Intercept: Grand mean	3.99	.00	808.86***	11,189
Gender: Female	−.12	.01	−11.25***	11,189
Race: Minority	−.07	.01	−4.47***	11,189
High school GPA	.04	.00	7.91***	11,189
Pretest	.45	.01	47.95***	11,189
Cross−racial interaction	.01	.00	7.85***	11,189
HPW[a] working on campus	−.01	.00	−3.51**	11,189
HPW[a] studying/homework	.03	.00	7.88***	11,189
HPW[a] attending classes/labs	−.01	.00	−3.33**	11,189
HPW[a] socializing with friends	.01	.00	2.51*	11,189
Have been a guest in a professor's home	.03	.01	2.25*	11,189
Asked a professor for advice outside of class	.05	.01	4.92***	11,189
Challenged a professor's ideas in class	.10	.01	10.44***	11,189
Random Effect	**Variance Component**		**df**	**χ^2**
Institutions				
Have been a guest in a professor's home	.00230		94	114.46
Asked a professor for advice outside of class	.00124		94	109.04
Challenged a professor's ideas in class	.00201		94	122.32*
Majors				
Have been a guest in a professor's home	.00059		29	47.42*
Asked a professor for advice outside of class	.00016		29	36.38
Challenged a professor's ideas in class	.00004		29	26.71
Students	.23385			

To fully describe variance components, the statistics were reported using five-digit decimal

[a] *HPW* hours per week

* $p < .05$; ** $p < .01$; *** $p < .001$

strength of association between student–faculty interaction and academic self-concept varies across majors and/or institutions. To answer this question, we estimated a series of randomly varying effects models whereby the level-1 model was respecified by trimming down non-significant predictors (see "Analysis" section). Table 3 displays the results of the final, reduced randomly varying effects model.

The results of the fixed effect revealed that all three student–faculty interaction measures in the final randomly varying effects model are significantly and positively related to students' academic self-concept in their senior year even after controlling for the effects of their initial academic self-concept in their freshman year and other level-1 (student-level) variables. That is, the results suggest that students who more frequently visit a professor's home as a guest, ask a professor for advice outside class, and challenge a professor's ideas in class tend to report higher levels of academic self-concept in their fourth college year than those who do not or do so less frequently. Specifically, a 1-unit increase in visiting a professor's home as a guest, asking a professor for advice outside class, and challenging a professor's ideas in class was associated with .03, .05, and .10 unit increase in students' academic self-concept, respectively. Given that all these student–faculty interaction

measures employed the same coding scheme (i.e., three-point Likert scale: 1 = not at all to 3 = frequently), the results also suggest that the positive effect of challenging a professor's ideas in class on academic self-concept is relatively stronger than that of other two types of faculty interaction. Furthermore, the results of random effect showed that some of these positive effects are conditional depending on either academic majors or institutions, while others are not.

The result showed significant department (major)-level variation in the slope of having been a guest in a professor's home, meaning that the strength of relationship between having been a guest in a professor's home and students' academic self-concept varies significantly across academic majors. According to Raudenbush and Bryk (2002), we can calculate a useful parameter, the *range of plausible values,* using the results of the randomly varying effects model. This range is computed by the following formula:

$$\pi_q \pm 1.96\left(\tau_{qq}\right)^{1/2} \tag{6}$$

where $q = 0,\ldots,Q$ random coefficients in the level-1 model, and indicates how *much* of a difference in the slope exists across certain higher-level units (i.e., academic majors in this case). Applying the formula for our results, the 95 % plausible value range for the slope of having been a guest in a professor's home on academic self-concept was

$$.03 \pm 1.96(.00059)^{1/2} = (-.02,\ .08).$$

This result suggests that there is a substantial variability in the effect of having been a guest in a professor's home on students' academic self-concept across different academic majors, in which the effect (i.e., slope) ranges from −.02 to .08. In other words, the positive association between this type of student–faculty interaction and academic self-concept is not only stronger in some academic majors than others, but actually seems to be negative in some academic majors.

In contrast, the results revealed that the effect of other types of student–faculty interaction—i.e., asking a professor for advice outside of class and challenging a professor's ideas in class—on students' academic self-concept does not significantly vary across academic majors (τ_{c110}= .00016, $\chi^2_{(29)}$= 36.38, $p > .05$; τ_{c120}= .00004, $\chi^2_{(29)}$= 26.71, $p > .05$, respectively). Given that the results of fixed effect revealed the significantly positive relationship between these types of student–faculty interaction and students' academic self-concept, this result suggests that asking a professor for advice outside of class and challenging a professor's ideas in class tend to improve students' academic self-concept *regardless* of academic major. In other words, the positive association between such types of student–faculty interaction and students' academic self-concept seems more stable than the relationship between having been a guest in a professor's home and academic self-concept.

While it was not the main interest of our study, results also showed that the relationship between challenging a professor's ideas in class and academic self-concept significantly varies across institutions (τ_{b120}= .00201, $\chi^2_{(94)}$= 122.32, $p < .05$). Based on this finding, the slope of this faculty interaction measure was conditioned by five institutional-level variables when we specified our full model explaining randomly varying effects in the next stage of cross-classified multilevel modeling (as discussed earlier in the "Analysis" section).

Estimation of Full Model Explaining Randomly Varying Effects

We are informed by the results of the earlier analysis that the effect of having been a guest in a professor's home on students' academic self-concept does vary depending on their

academic majors, even after controlling for its variability across institutions. To further investigate these findings, we now examine *why* some academic majors have stronger association between this type of student–faculty interaction and academic self-concept than other academic majors. To address this research question, we specified and tested a full model explaining randomly varying effects, the final explanatory model.

Table 4 presents the results of the full model. Although this model was developed to examine certain departmental characteristics and conditions that moderate the relationship between student–faculty interaction and academic self-concept, it is also noteworthy that the results show that all three types of student–faculty interaction in the model significantly and positively related to academic self-concept in the fourth college year across all academic majors even after controlling for both student-, department-, and institution-level confounding effects.

Results show that four department-level variables significantly predicted the slope of having been a guest in a professor's home on academic self-concept. Results indicate the positive relationship between having been a guest in a professor's home and academic self-concept is relatively weaker in Investigative (e.g., Chemistry, Mathematics, Biology) and Enterprising (e.g., Journalism, Business Administration, Finance) academic major fields than in Artistic (e.g., Arts, Language/Literature) or Social (e.g., Philosophy, Sociology) majors. Both the departmental proportions of minority students and departmental average level of satisfaction with faculty accessibility also significantly and positively predicted the slope. In other words, this result suggests that the strength of relationship between having been a guest in a professor's home and academic self-concept tends to be stronger in academic majors where there are more students of color and students are more satisfied with ability to find a faculty or staff mentor.

Notably, those department-level variables explained substantial proportion of variance in the average effect (i.e., slope) of having been a guest in a professor's home on academic self-concept. As reported in the bottom panel of Tables 3 and 4, once a set of department-level variables were added to the full model to explain the disciplinary conditional effects of having been a guest in a professor's home on academic self-concept, the estimated variance of the slope of this faculty interaction measure dramatically dropped and lost its statistical significance (τ_{c100}= .00059, $\chi^2_{(29)}$= 47.42, $p < .05$ to τ_{c100}= .00002, $\chi^2_{(29)}$= 32.83, $p > .05$). According to Raudenbush and Bryk (2002), results of this study suggest that 96.6 % [(τ_{qq} randomly varying effects model—τ_{qq} full model)/ τ_{qq} randomly varying effects model = (.00059–.00002)/.00059 = .966] of the variance in the average effect of having been a guest in a professor's home on academic self-concept is explained by the departmental characteristics and conditions of the full model.

While five institutional-level variables—i.e., institutional type, control, selectivity, size, and percentage of minority students—were included in the full model to explain the institutional variability in the relationship between challenging a professor's ideas in class and academic self-concept (refer to the "Analysis" section and Table 3), none of the institution-level variables used in this study significantly predicted the slope of this type of faculty interaction on academic self-concept. The results seem to suggest that other institution-level variables that were not available in our data (e.g., gender and race composition of faculty, student–faculty ratio) might possibly contribute to the variability in the effects of challenging a professor's ideas in class on students' academic self-concept. Whereas a further examination of the institutional conditional effects observed in this study would be valuable, this investigation was not within the scope of the present study.

Table 4 Estimation of full model explaining randomly varying effects

Fixed effect	Coefficient	SE	*T* ratio	df
Intercept for academic self-concept				
Base	3.98***	.01	840.85	11,177
Gender (female)				
Base	−.12***	.01	−11.93	11,177
Race (minority)				
Base	−.07***	.01	−4.89	11,177
High school GPA				
Base	.04***	.00	8.80	11,177
Pretest				
Base	.45***	.01	51.43	11,177
Cross-racial interaction				
Base	.01***	.00	7.85	11,177
HPW[a] working on campus				
Base	−.01**	.00	−3.61	11,177
HPW[a] studying/homework				
Base	.03***	.00	8.07	11,177
HPW[a] attending classes/labs				
Base	−.01**	.00	−3.35	11,177
HPW[a] socializing with friends				
Base	.01*	.00	2.54	11,177
Have been a guest in a professor's home				
Base	.02*	.01	2.57	11,177
Artistic	.02	.02	.90	11,177
Investigative	−.06*	.02	−2.72	11,177
Enterprising	−.06*	.02	−2.46	11,177
% Female	.00	.00	−1.04	11,177
% Minority	.01*	.00	2.14	11,177
AVG: satisfaction with amount of contact	−.21	.14	−1.54	11,177
AVG: satisfaction with faculty accessibility	.33*	.15	2.20	11,177
Asked a professor for advice outside of class				
Base	.05**	.01	5.74	11,177
Challenged a professor's ideas in class				
Base	.10***	.01	9.25	11,177
Institutional type[b]	.00	.03	.07	11,177
Institutional control[c]	.01	.06	.08	11,177
Institutional selectivity[d]	.00	.00	.85	11,177
Institutional size[e]	–.00	.00	−.26	11,177
Institutional % minority	.00	.00	.67	11,177
Random effect	Variance component (χ^2)		df	χ^2
Institutions				
Challenged a professor's ideas in class	.00194		94	121.16*
Majors				

Table 4 continued

Random effect	Variance component (χ^2)	df	χ^2
Have been a guest in a professor's home	.00002	29	32.83
Students	.23466		

To fully describe variance components, the statistics were reported using five-digit decimal

[a] *HPW* hours per week

[b] Institutional type: 0 = university, 1 = 4 years college

[c] Institutional control: 0 = public, 1 = private

[d] Institutional selectivity: the mean score of entering freshmen on the Verbal plus Mathematical portions of the scholastic aptitude test

[e] Institutional size: IPEDS Fall 2007 full-time equivalent undergraduate enrollment

* $p < .05$; ** $p < .01$; *** $p < .001$

Limitations

This study is limited in several aspects. First, given the nature of the CIRP data, the sample for the study is disproportionately biased toward White female students at private liberal arts colleges. Although we tried to compensate for this shortcoming by controlling for student race, gender, and other input characteristics in our multilevel models, this limitation should be considered when interpreting the findings of the study. Participation bias in the CIRP surveys is also reflected in the academic disciplines represented in the sample. That is, students in Realistic (e.g., Drafting or Design, Mechanics) and Conventional (e.g., Secretarial Studies, Data Processing) majors were underrepresented in our sample; hence, the effect of student–faculty interaction in Realistic and Conventional majors could not be examined in this study. Further, we excluded academic majors that had fewer than 100 respondents nationwide from the study sample to enhance the reliability of our multilevel models. In this sense, we were somewhat limited in our ability to capture the broad categories of academic majors (i.e., academic disciplines). It should be also noted that while the validity and reliability of academic self-concept factor scale of this study were statistically sound, we might overestimate the contribution of students' writing ability to the factor scale. Use of a secondary dataset is another limitation of the study. While the use of data from a national longitudinal survey of college students improved the reliability and generalizability of our findings, it constrained the pool of variables we could examine in this study. Lastly, while some studies have pointed out the reciprocal nature of student–faculty interaction and college student outcomes (e.g., Kim 2010; Pascarella & Terenzini 1991, 2005; Terenzini et al. 1996), this study could not address the issue of causality between faculty contact and student outcomes because the study utilized an observational data with correlational research design. Therefore, all the findings presented in this study should be interpreted as correlational connections between variables rather than causal connections.

Discussion

As stated earlier, whereas research on the association between student–faculty interaction and college outcomes is abundant, little is known about the conditional effects of faculty interaction—i.e., how the effects vary by different student subgroups. This is especially

evident when it comes to *group*-level conditional effects (e.g., differential effects by academic majors, departments, or disciplines). Using a nationwide college student dataset, this study attempted to improve our understanding of the group-level conditional effects of student–faculty interaction by examining the function of academic majors in explaining the effects of student–faculty interaction on students' academic self-concept. Overall, our findings break new ground by highlighting how the relationship between student–faculty interaction and students' academic self-concept varies across academic majors and identifying departmental conditions that contribute to such disciplinary effects.

First, we found that the relationship between student–faculty interactions and students' academic self-concept varies by the type of interaction. For example, talking with faculty either during or outside of office hours was not significantly related to students' academic self-concept once other types of student–faculty interaction measures were controlled, while challenging a professor's ideas in class and asking a professor for advice outside of class tended to improve their academic self-concept in the same situation. Further, the strength of the association between having been a guest in a professor's home and students' academic self-concept significantly varied by academic major. That is, students in some academic majors tended to benefit more or less from this type of faculty contact than did their peers in other academic majors. This finding is consistent with a study by Kim and Sax (2011) which showed that the impact of student–faculty interaction (measured by general faculty contact and research engagement with faculty) significantly varied by academic major. However, the present study took a step further by showing that these disciplinary effects also depend on the *type* of student–faculty interaction. That is, our findings indicate that, for several types of student–faculty interaction (e.g., asking a professor for advice outside of class, challenging a professor's ideas in class), the strength of relationship between faculty interaction and academic self-concept is relatively stable across academic majors (though sometimes variant across different institutions).

Our findings also shed some light on the departmental characteristics and conditions that contribute to the effects of student–faculty interaction that we did find to vary across academic majors. With regard to disciplinary typology (i.e., broad clusters of academic majors), the strength of association between visiting professors in their home and academic self-concept tended to be weaker in Investigative (e.g., Biology, Engineering) and Enterprising (e.g., Business, Marketing) fields than in Artistic (e.g., Arts, Language/Literature) and Social (e.g., Philosophy, Sociology) fields. Prior research offers some possible explanations for this finding. One immediate explanation is that faculty in Investigative and Enterprising environments are less likely to interact with their students than their counterparts in Artistic and Social fields (Umbach 2006). We might simply assume that students in Investigative and Enterprising academic majors benefit relatively less from their experience of visiting professor's home compared to their peers in other academic fields because they are less likely to visit a professor's home. Our study did show that students in Investigative and Enterprising fields were less likely to visit a professor's home as a guest than did others in Artistic and Social fields (refer to Table 2). Another possible explanation is that faculty in Investigative and Enterprising environments tend to use different pedagogical strategies to promote students' learning and development (Milem & Umbach 2003; Milem et al. 2004; Smart & Thompson 2001; Umbach 2006; Umbach & Milem 2004). Specifically, Smart and Thompson (2001) found that faculty in Investigative (and Enterprising) environments encourage students to develop their analytical, mathematical, and scientific abilities more so than their colleagues in other academic environments, while faculty in Artistic (and Social) environments more strongly encourage students to develop their innovation, creativity, and literary abilities. Considering the

disciplinary difference in normative intellectual priorities, perhaps students in Investigative and Enterprising fields do not develop as much in academic self-concept from the experience of visiting a professor's home because other aspects of faculty interaction, such as challenging a professor's ideas in class, serve better in that function.

When it comes to departmental conditions, the beneficial effect of students' visiting a professor's home on their academic self-concept tended to be greater in academic majors with higher percentages of racial minority students. This finding is a key addition to our understanding of how structural diversity—i.e., proportional representation of students from different racial groups (Hurtado et al. 1998, 1999)—might enhance college student outcomes. While existing research has documented that attending more racially diverse institutions is related to increased cross-racial interaction and positive educational outcomes (Antonio 2001; Astin 1993; Chang 1996, 1999; Chang et al. 2006; Gurin 1999; Hurtado 2003), our finding suggests that structural diversity positively influences college outcomes (academic self-concept in this case) by maximizing the educational benefits of a desired college experience such as student–faculty interaction.

Furthermore, the positive effects of being a guest in a professor's home seemed to be stronger in majors where students are more satisfied with faculty accessibility. In other words, students who are in academic majors where they more easily find and access faculty members tend to benefit more from their experience of visiting a professor's home than students in other majors who have relatively limited access to faculty. Interestingly, once we controlled for departmental averages of student satisfaction with faculty accessibility, average departmental satisfaction with *amount* of faculty contact lost significance in predicting the effect of being a guest in a professor's home on academic self-concept. In other words, simply increasing the frequency of student–faculty contact may not guarantee favorable student outcomes; it may be even more important to foster academic environments which sustain and magnify the benefits of student–faculty interaction (in this case, promoting greater accessibility to faculty). This conclusion is consistent with prior research (Kim 2010; Kim & Sax 2009, 2011).

Finally, our findings highlight the significance of student–faculty interaction as it relates to psychosocial college outcomes. All the three student–faculty interaction measures of this study had a significant positive effect on students' academic self-concept, even after controlling for an intensive set of student-, department-, and institution-level confounding effects. This finding suggests that generally speaking, students can benefit from interacting with their faculty members irrespective of their academic majors when it comes to academic self-concept, although some students benefit more or less than others depending on academic majors and/or institutions. As discussed earlier, while higher education scholars have established the positive association between student–faculty interaction and various college outcomes, they tend to focus on academic and cognitive outcomes, relatively ignoring psychosocial outcomes. Findings from this and other recent studies (Cokley 2000b; Clark et al. 2002; Cole 2007, 2011; Kim 2010; Kim & Sax 2009) do point out the need for further study of how student–faculty interaction shapes college students' psychosocial outcomes.

Implications and Conclusions

This study builds on previous studies on the conditional effects of student–faculty interaction that showed how the relationship between student–faculty interaction and college outcomes varies by students' demographic characteristics such as gender and race, by

examining the function of students' academic sub-environments (i.e., academic major in this case) on the educational efficacy of faculty contact. In this manner, the findings of this study make a key contribution to our understanding of disciplinary college impact and provide important theoretical and practical implications.

First, our findings validate the disciplinary effects of college experiences in general, and the basic premise of Holland's theory in particular. Higher education researchers have established the potential association between disparate academic sub-environments and students' learning and development (e.g., Pascarella & Terenzini 2005; Pike & Killian 2001; Pike et al. 2012; Smart & Umbach 2007; Umbach 2006; Umbach & Milem 2004). Most previous studies relied on Holland's theory to examine how the structural and contextual environments of different academic environments (mainly manifested by attitudes and behaviors of faculty) reflect different personality types proposed by Holland and uniquely shape student development by reinforcing and rewarding such personalities. With regard to student–faculty interaction, Pike et al. (2012) and Umbach (2006) found that Artistic and Social disciplines tend to report higher levels of student–faculty interaction compared to Investigative and Enterprising disciplines, which was also the case in this study. Our study supports and extends those earlier findings by showing that not only do the patterns and effects of student–faculty interaction vary by academic majors, but also that some departmental characteristics and conditions contribute to such disciplinary variance. In a methodological sense, the existence of disciplinary effects of college also justifies the use of multilevel modeling, or at least the need to control for academic majors, in order for college student data to adequately address its hierarchal structure. Indeed, some recent studies (e.g., Cole 2007; Kim & Sax 2011) employed multilevel modeling to examine the possible cross-level effects related to student–faculty interaction and generally support the conclusion from this study.

Additional theoretical implications exist concerning the importance of the nature of student–faculty interaction and the need for further study of how that nature shapes the educational efficacy of the interaction. Our findings show that the effects of student–faculty interaction vary not only by students' academic majors but also by the nature of the interaction. While all three types of student–faculty interaction in our final explanatory model (full model) were positively associated with students' academic self-concept, the association was more evident as it related to challenging a professor's ideas in class than other types of faculty contact. Previous studies have also documented the differential effects of student–faculty interaction dependent on the nature of the interaction (Cole 2007; Dika 2012; Kim & Sax 2009; Komarraju et al. 2010). This study adds to the imperative to develop and use student–faculty interaction measures that can address multiple dimensions of such interaction (Cox & Orehovec 2007), and it urges the need for researchers to illuminate the nuance of different types of faculty interaction and its implications on student learning and development.

The findings of this study also suggest important practical implications. Faculty members and student affairs professionals in higher education institutions need to pay greater attention to academic disciplines where students tend to engage relatively less in student–faculty interaction compared to other disciplines. Particularly, while students in some academic disciplines reported more or less frequent faculty interaction than did students in other disciplines (depending on the type of the interaction), we found that students in Enterprising fields (e.g., Business, Marketing, Management) reported the least frequent student–faculty interactions across all different types of faculty interaction measures in the study (except one), invested the fewest hours in talking with faculty during or outside of office hours, and were least satisfied with faculty interaction. Greater attention

to nuances in the effect of student–faculty interaction is even more important when we consider another finding of this study: that the effect of some types of student–faculty interaction (e.g., having been a guest in a professor's home) seem to be relatively weaker in Enterprising fields than in other disciplines. In other words, these findings suggest that students in Enterprising academic fields tend to not only interact with their faculty less frequently but also benefit less from the interaction. It is critical for higher education institutions and their personnel to acknowledge these disciplinary variations and foster a more "efficient" academic sub-environment where students not only are more frequently exposed to educationally meaningful college experiences such as student–faculty interaction but also gain more beneficial outcomes from the experiences.

While further studies should examine what characterizes the efficient academic sub-environment, our findings also provide some cues that inform our understanding of the environment. We found that the more racial/ethnic minority students there are in an academic major, the stronger the relationship between having been a guest in a professor's home and academic self-concept. This finding suggests that whatever the reasons might be, students who are in academic majors with higher percentage of students of color appear to be benefiting from the overall department climate that encourages positive relations with faculty as well as students. Thus, this study points to the importance of recruiting and retaining racially diverse student bodies (Antonio 2001; Astin 1993; Chang 1996, 1999; Chang et al. 2006; Gurin 1999; Hurtado 2003), and it suggests that the racially heterogeneous college environment may possibly facilitate more meaningful interactions between students and faculty.

Faculty accessibility is another factor that possibly enhances the association between faculty interaction and students' academic self-concept. This study revealed that the positive relationship between having been a guest in a professor's home and students' academic self-concept was more pronounced among students who are in academic majors where faculty members were more accessible to their students. Whereas other research has shown faculty accessibility cues to significantly affect the amount of student–faculty interaction, shaping students' perception of their faculty members' attitude toward students (Cotten & Wilson 2006; Wilson et al. 2011, 1974), our research shows that faculty accessibility might possibly facilitate an educational environment where students benefit more, at least in terms of academic self-concept, from their interaction with faculty. Faculty members can communicate their accessibility and enthusiasm to interact with students both in the classroom (e.g., calling students by their names, taking students' questions seriously, valuing students' comments) and outside of the classroom (e.g., holding regular office hours, inviting students to assist faculty research, having informal on- and off-campus meetings, providing open communication channels via email, phone call, and others). These cues might be even more significant for students who are in Enterprising (e.g., Business, Marketing, Management) and Investigative fields (e.g., Engineering, Mathematics, Biology) where students have fewer opportunities for student–faculty interaction and may be hesitant to seek out interaction with their faculty.

Overall our findings show that not only does the educational efficacy of student–faculty interaction vary by students' academic majors, but that some departmental characteristics and conditions are essential to explain the disciplinary effects of faculty contact. As higher education institutions consider how they can foster more frequent and meaningful interactions between students and faculty, we suggest that campuses should acknowledge and consider the role that academic sub-environments play in shaping the association between student–faculty interaction and desired college outcomes.

Appendix

See Appendix Tables 5 and 6.

Table 5 Academic majors of CIRP data classified by Holland's academic environments

Holland's classification	Student level		Major level		Academic majors
	N	%	*N*	%	
Realistic	286	2.0	6	7.1	Electrical or Electronic Engineering; Mechanical Engineering; Drafting or Design; Electronics; Mechanics; Military Science
Investigative	2,940	20.8	24	28.6	Biology (general); Biochemistry or Biophysics; Botany; Environmental Science; Marine (Life) Science; Microbiology or Bacteriology; Zoology; other Biological Science; Aeronautical or Astronautical Engineering; Civil Engineering; Chemical Engineering; Astronomy; Atmospheric Science; Chemistry; Earth Science; Marine Science; Mathematics; Physics; Statistics; Other Physical Science; Health Technology (medical, dental, laboratory); Investigative; Economics; Geography
Artistic	1,987	14.0	8	9.5	Art (fine and applied); English; Language and literature (except English); Music; Speech; Theater or Drama; Music or Art Education; Architecture or Urban Planning
Social	4,559	32.2	16	19.0	History; Philosophy; Theology or Religion; Elementary Education; Physical Education or Recreation; Special Education; Home Economics; Library/Archival Science; Social; Anthropology; Ethnic Studies; Political Science; Psychology; Social Work; Sociology; Women's Studies; Law Enforcement
Enterprising	2,527	17.8	12	14.3	Journalism; Business Administration (general); Finance; International Business; Marketing; Management; Business Education; Computer Engineering; Industrial Engineering; Law; communications; Computer Science
Conventional	572	4.0	3	3.6	Accounting; Secretarial Studies; Data Processing or Computer Programming
Other (not in Holland)	1,286	9.1	15	17.9	Other Arts and Humanities; Other Business; Secondary Education; Other Education; Other Engineering; Medicine, Dentistry, Veterinarian; Therapy (Occupational, physical, speech); Other Professional; Other Social Science; Building Trades; Other Technical; Agriculture; Forestry; Kinesiology; Other Field
Total	14,157	100.0	84	100.0	

This table presents descriptive statistics of academic majors in the original data ($n = 14{,}450$). Of 14,450 students in the original data, 293 students did not declare their majors; hence, they were excluded from this descriptive analysis. Academic majors in Realistic, Conventional, and Other (not in Holland) were excluded from the statistical analysis in this study. Academic majors that had fewer than 100 respondents nationwide were also excluded from the study sample (see Data Source and Sample)

Table 6 Coding schemes and descriptive statistics of variables

Variable	Coding scheme	Mean	SD
Student-level variables			
Dependent variable			
Academic self-concept: Posttest (2007)	Factor scale	3.99	.59
	Self-rating: academic ability		
	Self-rating: intellectual self-confidence		
	Self-rating: writing ability		
Independent variables			
Have been a guest in a professor's home	Three-point scale: 1 = not at all to 3 = Frequently	1.65	.62
Asked a professor for advice outside of class	Three-point scale: 1 = not at all to 3 = Frequently	2.17	.61
Challenged a professor's ideas in class	Three-point scale: 1 = not at all to 3 = Frequently	1.75	.62
Hours per week talking with faculty during office hours	Eight-point scale: 1 = none to 8 = over 20 h	2.43	.91
Hours per week talking with faculty outside of class	Eight-point scale: 1 = none to 8 = over 20 h	2.23	.93
Faculty mentorship	CIRP Construct	50.24	8.64
	Faculty provided:		
	Encouragement to pursue graduate study		
	An opportunity to work on a research project		
	Advice and guidance about educational program		
	Emotional support and encouragement		
	A letter of recommendation		
	Help to improve study skills		
	Feedback about academic work		
	An opportunity to discuss coursework outside of class		
	Help in achieving professional goals		
Control variables			
Gender: female	Dichotomous: 0 = no, 1 = yes	.63	.48
Race: minority	Dichotomous: 0 = no, 1 = yes	.13	.33
High school GPA	Eight-point scale: 1 = D to 8 = A or A+	6.97	1.12

Table 6 continued

Variable	Coding scheme	Mean	SD
Academic self-concept: Pretest (2003)	Factor scale	3.86	.58
	Self-rating: academic ability		
	Self-rating: intellectual self-confidence		
	Self-rating: writing ability		
Cross-racial interaction	Factor scale (CIRP construct)	52.43	8.88
Hours per week working on campus	Eight-point scale: 1 = none to 8 = over 20 h	3.04	2.16
Hours per week studying/homework	Eight-point scale: 1 = none to 8 = over 20 h	5.52	1.43
Hours per week attending classes/labs	Eight-point scale: 1 = none to 8 = over 20 h	5.80	1.14
Studied with other students	Three-point scale: 1 = not at all to 3 = Frequently	2.38	.57
Hours per week socializing with friends	Eight-point scale: 1 = none to 8 = over 20 h	5.68	1.44
Department-level variables			
Typology variables			
Artistic (ref.: social)	Dichotomous: 0 = no, 1 = yes	.17	.37
Investigative (ref.: social)	Dichotomous: 0 = no, 1 = yes	.22	.41
Enterprising (ref.: social)	Dichotomous: 0 = no, 1 = yes	.21	.41
Department demographic variables			
% Female students		63.20	17.37
% Minority students		13.24	3.31
Department climate variables			
AVG: satisfaction with amount of faculty contact		4.20	.12
AVG: satisfaction with faculty accessibility		3.99	.08
Institution-level variables			
Institutional type: 4 years college	Dichotomous: 0 = no, 1 = yes	.85	.36
Institutional control: Private	Dichotomous: 0 = no, 1 = yes	.91	.29
Institutional size (undergraduate enrollment)		3601.50	4643.83
Institutional selectivity (mean score of SAT verbal and math)		1131.98	114.77
% Students of color		19.37	15.08

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