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A Structural Model of the Relationship Between Student–Faculty Interaction and Cognitive Skills Development Among College Students

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Abstract Using structural equation modeling, this study attempted to untangle the underlying mechanisms among student–faculty interaction, classroom engagement, and cognitive skills development by examining the role played by students' academic self-challenge and sense of belonging on the relationships among the variables. The study utilized data from the 2010 University of California Undergraduate Experience Survey and a sample of 5169 senior students across 10 campuses. This study found that student–faculty interaction is related to greater levels of classroom engagement, which in turn facilitates students' cognitive skills development and that students' academic self-challenge and sense of belonging mediate the relationship between faculty interaction and classroom engagement. Thus, the findings suggest that the pathways from student–faculty interaction to a desired college outcome seem more complex than those hypothesized in traditional college impact theories or models. The study discusses the theoretical and practical implications of the findings.

Keywords Student–faculty interaction · Cognitive skills development · Academic self-challenge · Sense of belonging · Classroom engagement · Structural equation modeling

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Introduction

Faculty members are thought to be one of the major socializing agents in the college environment, and it has been widely heralded that frequent and positive interactions between students and faculty enhance students' persistence and retention in higher education (Hernandez 2000; Jackson et al. 2003; Pascarella and Terenzini 2005). A number of empirical studies also found that student–faculty interaction precipitated a broad range of favorable college outcomes such as higher grade point average (Anaya and Cole 2001; Dika 2012; Kim 2010; Kim and Sax 2009), growth in cognitive or intellectual skills (Bean 1980; Endo and Harpel 1982; Kim and Sax 2011; Pascarella and Terenzini 1976, 1977, 1978, 1979; Terenzini and Pascarella 1977, 1978, 1980; Volkwein et al. 1986), greater educational aspiration (Kim 2010; Kim and Sax 2009), and gains in academic self-concept (Clark et al. 2002; Cokley 2000a, b; Cole 2007, 2011; Kim and Sax 2014).

The positive link between student–faculty interaction and student outcomes can be partially explained by the socialization process of college students as proposed by college impact theories or models (Astin 1984; Pascarella 1980; Tinto 1987, 1993; Weidman 1989). That is, it has been suggested in the theories or models that interactions between students and faculty facilitate greater levels of academic engagement for students, which in turn leads them to move toward larger gains in their college outcomes. However, it is still unclear *how* and *why* interactions between students and faculty motivate students toward greater levels of academic engagement. To untangle the underlying mechanisms among student–faculty interaction, academic engagement, and college outcomes, we incorporate concepts of academic self-challenge and sense of belonging. Specifically, we hypothesize that student–faculty interaction is positively related to students' academic self-challenge and sense of belonging, both of which lead to greater levels of classroom engagement in critical reasoning and in turn facilitate greater gains in students' cognitive skills. Through the use of structural equation modeling, this study seeks to answer the following three research questions: (1) What are the direct and indirect relationships among student–faculty interaction, classroom engagement in critical reasoning, and cognitive skills development among college students? (2) Do academic self-challenge and sense of belonging mediate the relationship between student–faculty interaction and classroom engagement in critical reasoning? (3) Does classroom engagement in critical reasoning mediate the relationship between student–faculty interaction and cognitive skills development?

Literature Review

Effects of Student–Faculty Interaction

Many studies of college student success utilize a sociological or college impact framework when explaining the ways college environments and institutional agents contribute to student success (Astin 1984; Kuh 2003; Tinto 1987, 1993; Weidman 1989). Numerous empirical studies have situated faculty members as one of the most important institutional agents that impact students (e.g., Astin 1977, 1993a; Dika 2012; Kim 2010; Kim et al. 2009; Kim and Sax 2009, 2011, 2014; Kuh 1995; Kuh and Hu 2001; Lundberg and Schreiner 2004; Pascarella 1980, 1985; Pascarella and Terenzini 1976, 1991, 2005; Sax et al. 2005; Strauss and Terenzini 2007; Thompson 2001). Studies of student–faculty

interaction have identified multiple positive outcomes from the interaction, both direct and indirect. Some direct benefits of student–faculty interaction include students' intellectual or personal development and satisfaction (Astin 1993a; Bean 1980; Endo and Harpel 1982; Kim and Sax 2009, 2011; Pascarella and Terenzini 1976, 1977, 1978, 1979; Terenzini and Pascarella 1977, 1978, 1980; Volkwein et al. 1986), stronger commitment to graduate (Pascarella and Terenzini 2005), and gains in vocational preparation (Kuh and Hu 2001). Particularly valuable are frequent student–faculty interactions with an educational component (Pascarella and Terenzini 2005). In a study of community college students, Tinto (1997) found that when faculty structured the classroom to focus on collaborative and interdisciplinary learning, students enjoyed a higher persistence rate from semester to semester and also higher transfer rates from two-year to four-year institutions. Gasiewski et al. (2012) cite this study as evidence of the "association between faculty-student interactions and increased student learning and engagement" (p. 231).

Academic Self-Challenge

Central to students' academic success is their ability to challenge themselves to meet academic goals (Bandura 1986; Schunk and Zimmerman 1994). A cyclical process occurs by which successful students set goals for themselves, invest effort to meet those goals, and notice progress toward goal attainment (Schunk 1996; Zimmerman 1995). This cycle helps successful students see that they are capable learners and it reinforces their own academic goal setting. One of major elements of this process is the ability of students to observe their own behavior, make judgements about it, and then react to those observations and judgments. Students' motivation to attempt challenging academic tasks increases when they see that their effort is leading to the accomplishment of their academic goals (Schunk 1996).

Ryan and Deci's self-determination theory (2000b) posits that relationships between students and teachers increase students' motivation to achieve their goals. The theory holds that people internalize the goals of others whom they value, and that internalization leads to greater motivation for goal achievement. Empirical studies have validated the theory. Ryan and Deci (2000a) found that teachers' positive feedback about students' performance increased their intrinsic motivation such as academic self-challenge as well as their investment of effort in academic work, while negative feedback decreased their motivation and academic engagement. Using a college student sample, Kuh and Hu (2001) demonstrated that as student–faculty interaction increased, students invested more effort in educationally productive activities. Similarly, Twale and Sanders (1999) described student–faculty interaction as beneficial because it encouraged students to become more involved in the academic aspects of campus life. Tauber (1997) also found that positive student–faculty relationships enhanced students' confidence in their ability to reach the high expectations of faculty. Thus, one way student–faculty interaction contributes to student learning is by indirectly motivating students to challenge themselves academically.

Sense of Belonging

Another indirect way that student–faculty interaction may contribute to student learning is through enhancement of students' sense of belonging at the institution. Sense of belonging is part of the sociological construct for cohesion; it is about the extent to which people feel that they belong, are members of a community, and feel that they are a part of the community (Bollen and Hoyle 1990). Hurtado and Carter (1997) found that sense of belonging was an important mediating variable that contributes to student success,

particularly for historically marginalized student groups whose culture and value are not dominant on campus. For the Latino/a students who comprised the sample in Hurtado and Carter's (1997) study, a supportive racial climate was central to their sense of belonging. Another study found that student–faculty interactions contributed to sense of belonging for White students, but not for African American students; for both groups, sense of belonging contributed to students' intention to persist (Hausmann et al. 2009).

Meeuwisse et al. (2010) divided student–faculty interaction into formal and informal domains. The formal domain measured student interaction with faculty related to classroom discussion and advice, while informal interactions were purely social interactions between students and faculty. They found that formal interactions with faculty contributed to sense of belonging and indirectly to academic progress through sense of belonging. Thus, they suggest that positive interactions between students and faculty create "antecedents" (p. 532) to students' sense of belonging, which then lead to academic progress. Conversely, another study found no relationship between faculty interaction and sense of belonging for students from a variety of ethnic groups, though for Hispanic/Latina/o students faculty interaction had a negative effect on sense of belonging (Johnson et al. 2007).

Classroom Engagement

In addition to fostering a sense of belonging, several studies have found that course-related student–faculty interaction functions to deepen student engagement in the classroom. In a study of first-year college students, Freeman et al. (2007) found that student perceptions of their instructors' warmth and openness was positively related to a sense of belonging and to student participation in the class. Class belonging predicted self-efficacy, intrinsic motivation, and perception that the academic tasks of the course were valuable. Students' sense of belonging in class increased when they perceived faculty as enthusiastic, friendly, and helpful and when they perceived encouragement from their instructors to participate in class.

Wilson et al. (1974) introduced the concept of accessibility cues of faculty that help students understand the extent to which faculty are accessible and interested in the questions of students. In a study of *science*, *technology*, *engineering, and mathematics* (STEM) courses, Gasiewski et al. (2012) found that students were more engaged in the classroom when faculty demonstrated behavioral and attitudinal accessibility cues, particularly in terms of care for students, humor, and passion for the topic of the course. They also found that students reported greater engagement in courses when faculty members communicated that student questions were valuable and when faculty expressed an understanding of their responsibility to help students succeed. Similarly, other studies suggest that students tend to be more engaged in their learning and obtain more favorable outcomes when their relationships with faculty and staff are meaningful (Crombie et al. 2003; Guiffrida et al. 2013). Umbach and Wawrzynski (2005) also found a positive relationship between course-related student–faculty interaction and student engagement in active and collaborative learning in the classroom.

Cognitive Skills

College students' cognitive skills and abilities are among the most essential outcomes of college education (Pascarella and Terenzini 2005); student–faculty interaction has been

heralded to significantly affect students' cognitive development during college (Astin 1993; Endo and Harpel 1982; Kim and Sax 2011; Kuh and Hu 2001; Pascarella and Terenzini 2005; Sax et al. 2005; Strauss and Terenzini 2007). Astin (1993b) categorized college outcomes into two domains: cognitive and affective. Outcomes in the cognitive domain included academic achievement, critical thinking, logic and reasoning. These are similar to what Pascarella and Terenzini (2005) defined as cognitive skills and intellectual growth. In their meta-analysis of the literature, Pascarella and Terenzini explain that though the terms for discrete cognitive skills may be slightly different from study to study, their commonality lies in their applicability across disciplines particularly related to processing information, communicating, reasoning, evaluating information, and making decisions. Bowman (2010) also defines cognitive skills as "specific skills and abilities in thinking, reasoning, and processing information; some of the most commonly examined attributes include critical-thinking and problem-solving skills" (p. 6). Similarly, Padgett et al. (2012) operationalized cognitive development in terms of students' change over time in valuing learning, gains in reading and writing, critical thinking, and moral development. The Collegiate Assessment of Academic Proficiency (CAAP) from American College Testing Program (ACT) operationalizes cognitive gains in terms of reading, mathematics, and critical thinking, and it has been used to measure college students' cognitive growth over time (Cruce et al. 2006; Seifert et al. 2007).

Conceptual Framework

Figure 1 shows the hypothesized structural model for the relationship between student–faculty interaction and cognitive skills development. The hypothesized structural model was developed from the literature on cognitive skills development among college students, with further backing from research on student–faculty interaction and student motivation. Informed by Pascarella's (1985) general model for assessing change, the model assumed that student–faculty interaction has both direct and indirect (mediated by academic self-challenge, sense of belonging, and classroom engagement) relationships with students'

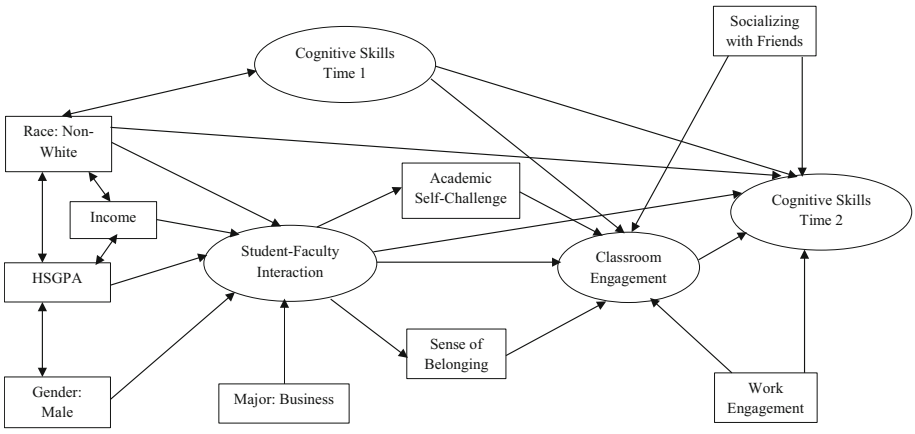

Fig. 1 Conceptual model for the relationship between student–faculty interaction and cognitive skills development

cognitive skills at their senior year (Cognitive Skills Time 2). In terms of the indirect relationship, it has been generally understood from the previous studies that the association between student–faculty interaction and student outcomes tends to be indirect, being mediated by a greater level of student involvement in other desired practices such as classroom engagement in this case (Pascarella and Terenzini 1991, 2005; Tinto 1993; Twale and Sanders 1999). Further, for an attempt to address the *why* of the link between student–faculty interaction and greater student engagement, we added two mediating variables—academic self-challenge and sense of belonging—to the paths from faculty interaction to classroom engagement in our hypothesized model. A substantial body of research argues that teachers'/faculty members' support of students' academic self-challenge and sense of beloning is pivotal to students' ideal engagement and learning (Hurtado and Carter 1997; Kuh and Hu 2001; Meeuwisse et al. 2010; Ryan and Deci 2000a; Tauber 1997; Twale and Sanders 1999). We assume that faculty members can communicate this support via their interactions with students both inside and outside of the classroom. Therefore, our model hypothesized that frequent student–faculty interaction enhances students' academic self-challenge and sense of belonging, which motivates students' greater level of classroom engagement, and which in turn facilitates their greater gains in cognitive skills.

Furthermore, based on findings from the literature, a set of student input characteristics and other college experiences were presumed to have either direct or indirect relationships with student–faculty interaction and cognitive skills. Studies indicate that students' social (or out-of-class) interaction with peers tends to improve students' cognitive growth (Inman and Pascarella 1998; Twale and Sanders 1999; Volkwein and Carbone 1994; Watson and Kuh 1996; Whitt et al. 1999). Hence, our model presumed that socializing with friends affects students' cognitive skills directly or indirectly through their classroom engagement. Given the research that work responsibilities during the college years tend to negatively affect students' academic engagement and growth in cognitive skills (Inman and Pascarella 1998; Terenzini et al. 1994), we also assumed negative relationships between work engagement and both classroom engagement and cognitive skills. Furthermore, there is salient evidence that the level or frequency of student–faculty interaction may differ by academic disciplines (Kim et al. 2015; Kim and Sax 2011, 2014; Umbach 2006). Particularly, studies consistently suggest that students who are in enterprising or business academic fields tend to report relatively lower levels of faculty interaction compared to their peers in other academic fields (Kim and Sax 2014; Umbach 2006). Therefore, our model presumed a direct negative path from being in business majors to student–faculty interaction.

Lastly, we added some students' pre-college characteristics to our hypothesized model in order to get a less biased parameter estimate when predicting our mediating and final endogenous variables. We included pretest measure of cognitive skills—i.e., students' self-assessment of their cognitive skills when they *entered* the college (Cognitive Skills Time 1)—as an exogenous variable of the model. In this manner, this study aimed to assess students' *growth* or *development* in their cognitive skills over the college years. Also, given the findings from previous studies that students' gender, race, socioeconomic status, and pre-college academic performance tend to influence the patterns of their interactions with faculty during college (Colbeck et al. 2001; Kezar and Moriarty 2000; Cole 2004; Kim 2010; Kim et al. 2009; Kim and Sax 2009; Lundberg and Schreiner 2004; Sax et al. 2005), we added students' gender and race identification, family income, and high school GPA to our model.

Method

Data Source and Sample

The data source for this study was the 2010 University of California Undergraduate Experience Survey (UCUES). The UCUES is an online survey of all University of California (UC) undergraduate students, which is administered biennially by the UC Berkeley Office of Student Research and managed by the UC Office of the President. The UCUES 2010 was administered to all undergraduate students at 10 UC campuses who were enrolled in winter or spring quarter 2010 and who were 18 years or older on April 1, 2010, yielding a 43 % response rate. The UCUES instrument includes a Core Module and five content-specific modules such as Academic Experience, Civic Engagement, and Student Development. While the core module was completed by all respondents, each of the five modules was administered to a randomly selected 20 % of students at each institution. This study utilized data solely from the Core Module, which gathers an intensive set of information on students' college experiences and outcomes (e.g., student–faculty interaction, peer interaction, extracurricular activities, classroom experiences, and various cognitive, affective, and civic outcomes) as well as their background characteristics and pre-college experiences.

Given that this study was designed to examine the effect of student–faculty interaction on the development of students' cognitive skills over their college years, the sample was limited to senior students who had been fully exposed to college experiences. The data screening procedure detected that 0.5–3.2 % of the cases for the variables in this study had missing data, and the missing data were replaced with values estimated from EM (expectation maximization) algorithm. Consequently, the final sample used for the analysis of this study was composed of 5169 senior students. Gender and ethnic composition of the analytical sample are as follows: 2127 (41.1 %) male and 3042 (58.9 %) female students; 1870 (36.2 %) White, 97 (1.9 %) Black, 629 (12.2 %) Latino, 2549 (49.3 %) Asian American, and 24 (0.5 %) other races.

Variables

Final Endogenous Variable

The ultimate outcome measure in the structural model of this study was cognitive skills in time 2 (i.e., cognitive skills in senior year). To assess the cognitive skills in time 2, a latent variable was developed via confirmatory factor analysis using students' self-reported level of proficiency in the following six items: (1) analytical and critical thinking skills, (2)

Table 1 Fit statistics for confirmatory factor analyses (n = 5169)

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA
Cognitive skills time 1	17.677	3	5.892	.999	.994	.031
Student–faculty interaction	20.716	2	10.358	.997	.992	.043
Classroom engagement in critical reasoning	33.078	4	8.270	.998	.993	.038
Cognitive skills time 2	31.063	6	5.177	.998	.994	.028

ability to write clearly and effectively, (3) ability to read and comprehend academic material, (4) ability to understand a specific field of study, (5) ability to prepare and make a presentation, and (6) other research skills. Tables 1 and 2 present the fit statistics, factor loadings, and internal consistency estimates for all latent variables of this study. The results from the tables suggest that all four latent constructs reached a good fit to the data and were within more than acceptable range of factor loadings and internal reliabilities.

Endogenous Variables

Besides the final endogenous variable, this study included four endogenous variables: student–faculty interaction, classroom engagement, academic self-challenge, and sense of belonging. All of these are mediating endogenous variables; therefore, they are predicted by one or more exogenous variables while predicting other endogenous variable(s). The first two endogenous variables are latent constructs, and they were developed via confirmatory factor analysis using four to six individual items (see Tables 1 and 2 to see

Table 2 Factor loadings and internal consistencies for confirmatory factor analyses (n = 5169)

Factor/item	Factor loading	α
Cognitive skills time 1		.84
Analytical and critical thinking skills time 1	.80	
Ability to write clearly and effectively time 1	.78	
Ability to read and comprehend academic material time 1	.78	
Ability to understand a specific field of study time 1	.64	
Ability to prepare and make a presentation time 1	.56	
Other research skills time 1	.49	
Student–faculty interaction		.80
Talked with faculty outside of class about course material	.87	
Communicated with a faculty member by email or in person	.77	
Interacted with faculty during lecture class sessions	.69	
Worked with a faculty on an activity other than coursework	.51	
Classroom engagement in critical reasoning		.88
Examined and assessed other methods and conclusions	.84	
Reconsidered own position after assessing other arguments	.75	
Incorporated ideas from different courses	.74	
Evaluated methods and conclusions	.72	
Generated new ideas or products	.66	
Used facts or examples to support viewpoint	.65	
Cognitive skills time 2		.84
Ability to read and comprehend academic material time 2	.78	
Analytical and critical thinking skills time 2	.77	
Ability to write clearly and effectively time 2	.74	
Ability to understand a specific field of study time 2	.69	
Other research skills time 2	.57	
Ability to prepare and make a presentation time 2	.56	

indicators of the latent variables). The last two endogenous variables, academic self-challenge and sense of belonging, were included in this study as observed variables. Academic self-challenge is a composite measure of two items that assessed the extent to which students (1) found a course so interesting that they did more work than was required and (2) chose challenging courses even though they might lower their GPA ($\alpha = .62$). Sense of belonging was assessed by another composite measure of two items. The items included the extent to which students (1) would choose to enroll at their institution and (2) feel that they belong at their institution ($\alpha = .93$).

Exogenous Variables

The model in this study included eight exogenous variables to account for possible confounding effects of students' pre-college characteristics, academic major, and other college experiences on our final and mediating endogenous variables. Students' pre-college characteristics contain race, gender, income, high school GPA, and cognitive skills time 1 (i.e., cognitive skills when they entered the college). Both race and gender variables are dichotomous variables with White and female coded as 0 and students of color and male coded as 1, respectively, in each variable. Income represents parents' annual income and was gauged by an 11-point scale ranging from 1 = less than $10,000 to 11 = $200,000 or more. To attain the information on students' high school GPA, we matched the UCUES 2010 data to the UC system record; hence, the high school GPA used in this study is a student's *actual* high school GPA rather than a self-reported measure. We also included a pretest measure of cognitive skills (cognitive skills time 1) as an exogenous variable of our model to capture a longitudinal change in students' cognitive skills, and the variable is a six-item latent construct representing students' self-assessment of their cognitive skills when they entered the college in the same six areas as our final endogenous variable (cognitive skills time 2). Given that students in business majors tend to have relatively lower levels of student–faculty interaction (Kim and Sax 2014; Umbach 2006), this study created a dichotomous variable using non-business majors as the reference group to capture students' academic field. While we may consider using a broader range of variables to measure students' academic disciplines, we decided to use a dichotomous variable to improve the model specification and identification by securing a favorable degree of freedom for the model estimation. Lastly, students' work engagement and socializing with friends were also included in the structural model of this study to address their possible effects on cognitive skills at time 2 (i.e., cognitive skills in their senior year) and classroom engagement. Both college experience variables assessed students' time allocation to the corresponding experience, using an eight-point scale ranging from 1 = 0 h per week to 8 = more than 30 h per week.

Analysis

This study utilized structural equation modeling (SEM) using AMOS 22.0 to examine direct and indirect relationships among pre-college characteristics, student–faculty interaction, academic self-challenge, sense of belonging, classroom engagement, and cognitive skills for college students. As an extension of the general linear model, SEM allows researchers to test more than one regression equation simultaneously. Particularly, presentation of both direct and indirect effects between variables is one of the major benefits of SEM and helped us uncover the complex dynamics among the variables in our structural model. For the SEM analysis in this study, we first specified a hypothesized structural

model based on empirical findings from previous research (refer to Conceptual Framework for details in model specification). Before estimating our structural model, we also conducted a series of confirmatory factor analyses to develop four reliable, latent constructs of the model (refer to Tables 1 and 2). Then, we estimated the structural model incorporating those latent constructs and other observed variables into a single model. Based on AMOS recommendations, the hypothesized structural model was modified through multiple iterations of respecification until the model reached a good fit to the data.

Results

Final Structural Model

Figure 2 displays the final structural model developed by the study, presenting standardized direct effects. Both the Chi square statistic and other fit indices indicate that the model has a good fit to the data ($\chi^2 = 3262.981$, $p < .001$; CFI = .950; TLI = .940; RMSEA = .039). Most parameter estimates were significant and consistent with our hypothesized model. Results of the final model showed that student–faculty interaction has both direct and indirect positive relationships with students' cognitive skills in their senior year, even after controlling for the effects of their initial cognitive skills and other confounding variables of the model. That is, the results suggest that students who interact more frequently with faculty members tend to eventually experience greater gains in their cognitive skills—regardless of whether the path is direct or not—during college years than those who do not or do so less frequently. Also, as assumed in our initial structural model, classroom engagement in critical reasoning mediated the relationship between student–faculty interaction and cognitive skills; and, students' academic self-challenge and sense of belonging intervened in the relationship between student–faculty interaction and classroom engagement in critical reasoning. In contrast, four structural paths hypothesized in the initial model of this study were statistically non-significant: (1) paths from work

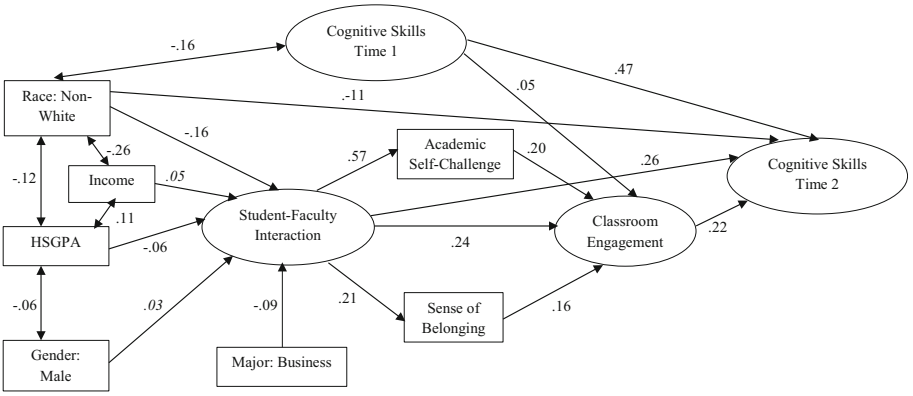

Fig. 2 Final structural model for the relationship between student–faculty interaction and cognitive skills development. Structural model (n = 5169), χ^2/df = 8.915, CFI = .950, TLI = .940, RMSEA = .039. All structural paths and correlations were statistically significant at the .001 level except two structural paths; the two exceptions were statistically significant at the .05 level and indicated with italicized text in the figure. Disturbances, errors, and observed variables used to create latent variables were omitted in the figure

Table 3 Summary of direct and indirect effects of the final structural model for the relationship between student–faculty interaction and cognitive skills development (n = 5169)

Variables	Direct effects (β)	Indirect effects (β)	R^2
Student–faculty interaction			.04
Income	.05*		
High school GPA	−.06**		
Major: Business	−.09**		
Race: Non-White	−.16**		
Gender: Male	.03*		
Academic self-challenge			.33
Student–faculty interaction	.57**		
Income		.03*	
High school GPA		−.03*	
Major: Business		−.05**	
Race: Non-White		−.09**	
Gender: Male		.02**	
Sense of belonging			.04
Student–faculty interaction	.21**		
Income		.01*	
High school GPA		−.01*	
Major: Business		−.02**	
Race: Non-White		−.03**	
Gender: Male		.01**	
Classroom engagement in critical reasoning			.21
Student–faculty interaction	.24**	.15**	
Academic self-challenge	.20**		
Sense of belonging	.16**		
Income		.02*	
High school GPA		−.02*	
Major: Business		−.04**	
Race: Non-White		−.06**	
Gender: Male		.01*	
Cognitive skills time 2			.44
Classroom engagement in critical reasoning	.22**		
Cognitive skills time 1	.47**	.01*	
Race: Non-White	−.11**	−.06**	
Student–faculty interaction	.26**	.09**	
Income		.02**	
High school GPA		−.02**	
Major: Business		−.03**	
Gender: Male		.01*	
Academic self-challenge		.05**	
Sense of belonging		.04**	

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

engagement to both classroom engagement in critical reasoning and cognitive skills time 2 and (2) paths from socializing with friends to both classroom engagement in critical reasoning and cognitive skills time 2. These results indicate that accounting for other variables in the model, students' work involvement and social peer interaction are unrelated to their classroom engagement and cognitive skills development; hence, the four paths were removed from the final model.

Direct and Indirect Effects

Results from the analysis showed several direct and indirect effects among variables in our structural model. Parameter estimates for all direct and indirect effects of the final structural model along with *R*-squared statistics are summarized in Table 3.

Relationship Between Student–Faculty Interaction and Cognitive Skills

Based on Pascarella's (1985) model and other empirical findings (refer to Literature Review and Conceptual Framework), this study hypothesized that student–faculty interaction has both direct and indirect relationships with students' cognitive skills development. Particularly, the study presumed that students' classroom engagement would serve as a mediating variable between students' interaction with faculty and their cognitive skills development. Consistent with previous studies (Abel 2013; Bean 1980; Crombie et al. 2003; Endo and Harpel 1982; Gasiewski et al. 2012; Guiffrida et al. 2013; Kim and Sax 2011; Pascarella and Terenzini 1976, 1977, 1978, 1979; Umbach and Wawrzynski 2005; Volkwein et al. 1986), results from the final structural model of this study supported these hypotheses. Results showed that student–faculty interaction is directly associated with students' cognitive skills at their senior year ($\beta = .26$, $p < .001$) after controlling for the effects of their initial cognitive skills when they entered the college and other confounding variables in the model. Besides the direct relationship, results also indicated that such faculty interaction had an indirect relationship with cognitive skills development mediated by classroom engagement. This finding suggests that students who interacted more frequently with their faculty members were more likely to be engaged in critical reasoning classroom activities ($\beta = .24$, $p < .001$); subsequently, the improved level of classroom engagement seemed to facilitate the development of students' cognitive skills ($\beta = .22$, $p < .001$).

Mediation Effects of Academic Self-Challenge and Sense of Belonging

The aforementioned findings suggest that student–faculty interaction is positively related to students' cognitive skills, being mediated by greater levels of classroom engagement, one of the key educational practices thought to contribute to college students' development and learning (Astin 1984, 1993a; Pascarella and Terenzini 1991, 2005). This finding is generally consistent with previous studies (Pascarella and Terenzini 1991, 2005; Tinto 1993; Twale and Sanders 1999). We now address the *why* of the favorable link between student–faculty interaction and classroom engagement, examining the role played by academic self-challenge and sense of belonging on the link. Informed by Ryan and Deci's (2000b) self-determination theory and other empirical findings (refer to Literature Review and Conceptual Framework), this study assumed that student–faculty interaction is related to students' greater levels of academic self-challenge and sense of belonging, which is

positively associated with students' engagement in critical reasoning classroom activities, and which in turn facilitates their greater gains in cognitive skills. Our results did show that there is a significant association among student–faculty interaction, those two mediating factors, and classroom engagement. We found that student–faculty interaction tended to be positively related to students' academic self-challenge ($\beta = .57$, $p < .001$) and sense of belonging ($\beta = .21$, $p < .001$); and such improved academic self-challenge ($\beta = .20$, $p < .001$) and sense of belonging ($\beta = .16$, $p < .001$) seemed to be associated with greater classroom engagement in critical reasoning activities.

While the findings revealed the mediation effect of academic self-challenge and sense of belonging on the relationship between student–faculty interaction and classroom engagement, it was also interesting to find that student–faculty interaction had a significant direct effect on classroom engagement ($\beta = .24$, $p < .001$), even after controlling for the mediation effects of academic self-challenge and sense of belonging. This finding reveals that both academic self-challenge and sense of belonging *partially* mediated the relationship between student–faculty interaction and classroom engagement. Indeed, we specified and tested an alternative model to examine whether the intervening variables (i.e., academic self-challenge and sense of belonging) have a complete or partial mediation effect. The analysis showed that once we constrained the path coefficient from student–faculty interaction to classroom engagement to 0, the model fit became significantly worse ($\Delta\chi^2_{(1)} = 157.884$, $p < .001$), supporting the partial mediation assumption among the variables (see Table 4).

Student Input Characteristics, Academic Majors, and Cognitive Skills

Results also revealed some interesting direct and/or indirect relationships between student input characteristics and cognitive skills development. As expected, students' initial level of cognitive skills when they entered the college (i.e., cognitive skills time 1) had the strongest positive direct relationship ($\beta = .47$, $p < .001$) with the level of cognitive skills in their senior year (i.e., cognitive skills time 2). Also, the initial level of cognitive skills had an indirect positive relationship with the level of cognitive skills in the senior year, mediated by greater classroom engagement in critical reasoning. These results indicate that students who had higher levels of cognitive skills when they entered the college tended to be more engaged in classroom activities on critical reasoning during college, which in turn facilitated larger growth in their cognitive skills over the college years. We also found that being a student of color had both direct and indirect negative relationships with students' cognitive skills development. These results suggest that students of color tend to report lower level of cognitive skills at their senior year compared to their White counterparts,

Table 4 Test of mediation effect between student–faculty interaction and critical reasoning classroom engagement: fit statistics for the original and an alternative model

Model	χ^2	df	CFI	$\Delta\chi^2$	Δdf	p	ΔCFI
Original Model (n = 5169)	3262.981	366	.950				
Alternative model: The direct path coefficient from student–faculty interaction to critical reasoning classroom engagement is constrained to 0 (n = 5169)	3420.865	367	.947	157.884	1	<.001	.003

even after controlling for the confounding effects of their initial level of cognitive skills when they entered the college. In addition, our results showed that students of color were less likely to interact with their faculty members than their White peers; this lower level of faculty interaction in turn adversely affected their cognitive skills development. In contrast, male students and higher family income students seemed to have greater levels of faculty interaction than did their female and lower family income counterparts; this higher level of student–faculty interactions possibly contributed to larger gains in cognitive skills among male and higher family income students.

When it comes to the relationship between academic major and cognitive skills, our results indicated that majoring in business seemed to have an indirect negative relationship with students' cognitive skills development, mediated by a lower level of student–faculty interaction. These results suggest that students who were in Business majors were less likely than their peers in other academic majors to interact with faculty members; subsequently, the lesser interaction with faculty appeared to be negatively associated with their growth in cognitive skills.

Limitations

While this study makes numerous contributions to the study of student–faculty interaction, it is limited in several aspects. Perhaps the greatest limitation in the present study is that the dataset is not longitudinal. While we were able to capture a longitudinal change in students' cognitive skills by measuring both students' retrospective assessment of their cognitive skills when they entered the college (cognitive skills time 1) and their current assessment of the skills in their senior year (cognitive skills time 2), these variables were both measured on the 2010 survey; therefore, the change in cognitive skills measured in this study is a proxy. For the same reason, all the findings presented in this study should be interpreted as correlational connections between variables rather than causal connections, given that the survey used in this study assessed students' college experiences and educational outcomes simultaneously. Furthermore, some studies have suggested the alternative direction of the path between student–faculty interaction and student outcomes—e.g., students who have strong cognitive skills tend to interact with faculty more frequently—or the reciprocal nature of faculty interaction and student outcomes (Kim 2010; Pascarella and Terenzini 1991, 2005; Ragins 1999; Singh et al. 2009; Terenzini et al. 1996). However, this study could not address the issue of causality between student–faculty interaction and student outcomes, cognitive skills in this case, because the study employed a correlational research design along with an observational dataset. Use of a secondary dataset is another limitation of the study. There are some variables that might affect students' cognitive skills such as faculty behaviors (Edison et al. 1998; Pascarella et al. 1996) and use of information technology (Kuh and Hu 2000); however, these variables were not available in the UCUES data. Also, while the UCUES data may have three-level hierarchies where students are nested in academic departments, which are in turn nested in institutions, we assumed for the purpose of structural equation modeling that the data have no hierarchies. Thus, it should be noted when interpreting findings of the study that there may be aggregation biases derived from not accounting for the possible hierarchical structure of the data. Lastly, given that this study utilized data from large, public research universities, findings or implications of the study may not be generalizable to other types of institutions such as private, two-year, or non-doctoral universities.

Discussion and Implications

Using a statewide college student dataset, this study attempted to explain the underlying mechanisms through which student–faculty interaction facilitates students' cognitive skills development. Particularly, to address the *why* of the link between student–faculty interaction and greater classroom-based academic engagement, this study incorporated concepts of academic self-challenge and sense of belonging. Overall, findings of this study confirm findings from previous studies on student–faculty interaction and break new ground by highlighting how those two concepts mediate the relationship between student–faculty interaction, classroom engagement, and cognitive skills development.

First, findings of the study suggest that the pathways from student–faculty interaction to a desired college outcome (cognitive skills in this case) may be more complex than those hypothesized in traditional college impact theories or models (which relied on mostly sociological perspectives). Astin (1984) suggests in his involvement theory that active participation or engagement in college experience (such as student–faculty interaction) will lead to better college outcomes and greater development for college students. Similarly, Tinto (1987, 1993) and Pascarella (1985) argue that interactions with socialization agents on campus (e.g., faculty, staff, peers) contribute to students' persistence, learning, and development in college both directly and indirectly (mediated by institutional commitments or quality of student effort). While our findings confirm these connections between student–faculty interaction and desired college outcomes, we add to the literature on how student–faculty interactions influence student outcomes by addressing the role played by students' academic self-challenge and sense of belonging in the positive connections between faculty interaction and college outcomes. This study found that students who interact more frequently with their faculty members tend to have higher levels of academic self-challenge and sense of belonging than those who do not or do so less frequently. These greater levels of academic self-challenge and sense of belonging facilitate students' classroom engagement, which in turn promotes their cognitive skills development. These findings are consistent with Meeuwisse et al. (2010) and Gasiewski et al.'s (2012) findings of a relationship among student–faculty interaction, sense of belonging, and classroom engagement.

Another key finding is that student–faculty interaction has a direct positive effect on cognitive skills development even after controlling for the mediation effects of classroom engagement, academic self-challenge, and sense of belonging as well as the confounding effects of a set of student input and college environment variables. That is, the finding suggests that when students interact with their faculty members (i.e., talking, communicating, or working with faculty members both in and outside of class), they may be naturally exposed to various forms of challenges and responses that facilitate their growth in cognitive skills. While the positive effects of student–faculty interaction can be partially explained by its contribution to other desirable institutional practices such as classroom engagement (Cole 2007; Kuh and Hu 2001; Pascarella and Terenzini 1991, 2005; Tinto 1993; Twale and Sanders 1999), there is also a direct relationship between interacting with their faculty members and gains in cognitive skills development. This finding reemphasizes the need for promoting students' interaction with faculty in order to maximize their growth and development during the college years.

Perhaps one step toward encouraging faculty interactions is simply to inform faculty about the potential results from interacting with students. The positive relationship between student–faculty interaction and students' academic self-challenge observed in this study

indicates that the benefits of faculty contact include students doing more work than required and enrolling in difficult courses even at the risk to the GPA. If faculty understood that these benefits could result from their interactions with students, they might be more interested in such an investment of their time. Other benefits of faculty interaction include a greater sense of belonging and deeper academic engagement in the classroom. Faculty members face multiple demands on their time, and their success depends largely on making wise decisions about time spent that will result in student learning and development. Faculty may be more willing to invest more time with students when they understand the positive student outcomes that result from their interactions with students. Benefits such as students working harder in class, pursuing challenging work, and feeling like they belong at the institution could be powerful motivators to faculty members, but institutions rarely discuss these dynamics with faculty.

Student–faculty interaction requires an investment of time on the part of the faculty member, and interacting with students is not typically recognized as valuable in institutional reward structures for faculty (Fairweather 2002). This study operationalized student–faculty interaction in terms of talking together about course material outside of class, communicating by email or in person, interacting during class, and working together on an activity other than coursework. These behaviors require faculty to pay attention to students as individuals and to respond to them. The current study verifies that such attentions increase students' engagement in the classroom, sense of belonging, and willingness to challenge themselves academically; but it doesn't identify what causes faculty members to engage in these behaviors. Future research could investigate a similar model, but from the framework of identifying the predictors of these productive faculty behaviors.

The finding that student–faculty interaction predicted both academic self-challenge and sense of belonging, also answers some of the questions about the mechanism by which faculty-student interaction contributes to student success. Of the two constructs, academic self-challenge was a stronger predictor in terms of its positive contribution to students' cognitive skills development (being mediated by greater levels of classroom engagement). Academic self-challenge was also more strongly influenced by student–faculty interaction than was sense of belonging. One element of academic self-challenge as operationalized in this study was a measure of the extent to which students found a course so interesting that they did more work than was required and chose challenging courses even though they might lower their GPA. This finding has implications for the academic advising processes. Academic advisors should encourage students to pursue interesting courses, even if those courses might threaten their GPA. Some students face pressure from home to maintain a high GPA at all costs, and many students impose this pressure on themselves. However, the findings from this study suggest that such pressure could hinder students' actual learning and development (growth in cognitive skills in this case). Freedom from GPA as the ultimate prize could lead to greater learning and development for students if it enables them to pursue challenging courses and invest deeply in those courses. Faculty development programs could help faculty to raise student interest in the topics of their courses, perhaps so much that students would be willing to enroll in difficult courses even at the risk to their GPA. Colleges and universities should educate students and families about the benefits of undertaking difficult courses, and should work to help families to view the GPA as only one of several indicators of student success. This education could take place at orientation programs, through newsletters and electronic communication, and through programming throughout campus over the academic year.

Our findings also shed some light on the issue of equity in college impact, depending on students' racial background. The finding that student–faculty interaction contributed to

student cognitive gains is a double-edged sword. For students who have access to faculty, this is a positive finding. However, our model also shows that minoritized students had less access to student–faculty interactions compared to their White peers. Thus, minoritized students tended to be hindered not just in terms of less access to faculty, but also in terms of less access to the academic self-challenge, sense of belonging, classroom engagement, and cognitive gains that result from such interactions. This finding is consistent with previous findings that the patterns or effects of student–faculty interactions are moderated by race/ethnicity in ways that disadvantage minoritized students (Brayboy and Maughan 2009; Kim 2010; Kim and Sax 2009; Lundberg and Schreiner 2004). Therefore, the disparities in the beneficial effects of student–faculty interaction between minoritized and White students point out the need for further study of how faculty interactions shape the experiences and outcomes of minoritized students.

Previous studies have found that minoritized students routinely encounter challenges in their interactions with faculty on college campuses, particularly at predominantly White institutions (Brown and Robinson Kurpius 1997; Chang 2005; Flowers 2004; Jackson et al. 2003; Jackson and Smith 2001; Kodama et al. 2001; Pewewardy and Frey 2004) and those poor interactions can interfere with student learning (Brayboy and Maughan 2009). Some challenges include faculty who demean their cultures in the classroom (Brayboy 2004), students' fear that faculty hold negative perceptions about their racial or ethnic group (Schwitzer et al. 1999), students of color being overlooked by faculty members (Solórzano et al. 2001), and minoritized students' sense that their academic ability was not taken seriously (Fries-Britt and Turner 2001), even for students in a selective honors program (Fries-Britt 1998, Fries-Britt and Griffin 2007). However, when minoritized students' interactions with faculty were positive, the benefits included increases in student adjustment (Wolf and Melnick 1990), persistence (Jackson et al. 2003; Swisher et al. 1991), higher GPA (Allen 1992), sense of mattering to the institution (Dayton et al. 2004), learning (Lundberg 2007, 2010, 2012), and greater satisfaction with college (Cole 2008). As institutions improve student–faculty interaction for minoritized students, then gains in motivation and cognitive skills may also improve for this population. Because of this, efforts to increase student–faculty interaction must also include a strong focus on improving these relationships for minoritized students.

Because students prefer to interact with faculty of their own race or ethnicity (Noel and Smith 1996), one method for increasing such interaction is through hiring and retaining more racially and ethnically diverse faculty and supporting their work with students. Such efforts require authentic institutional commitment to equity and to policies that support equitable measures of achievement (Fries-Britt and Turner Kelly 2005; Joseph and Hirshfield 2010). Padilla (1994) developed the construct "cultural taxation" to describe a phenomenon common to minoritized faculty wherein they are expected to take on additional tasks at the university though those tasks are rarely rewarded. This taxation takes the form of additional committee work, serving as educators of the broader community regarding issues of race, and functioning in informal roles of advisor and mentor to minoritized students. An institution's decision to weigh student mentoring in the tenure process creates a more level playing field for faculty of color (Fries-Britt and Turner Kelly 2005). Though student mentoring is rarely factored into tenure decisions, faculty mentors are central to the success of minoritized students (Bensimon 2007; Reddick and Sáenz 2012).

Conclusion

The structural model of this study identified some additional factors that were hidden in the relationship between student–faculty interaction and cognitive skills development, suggesting that future research might consider these and other additional psychological or sociological elements when examining the pathways of student–faculty interaction to college outcomes. Future research should also disaggregate student racial/ethnic groups to test this model. Except for majoring in business, all the negative coefficients in our model were related to minoritized students. This finding indicates that minoritized students tend to benefit less from their college education than their White peers in terms of cognitive skills development, simply because of their minoritized status and its negative effects on other variables in the model. Because student–faculty interaction was the largest way in which minoritized students were hindered, future research should investigate why that happens and how it might be improved.

In conclusion, our findings provide new insight into the educational effects of student–faculty interaction by employing a structural model where both direct and indirect relationships among faculty interaction, academic self-challenge, sense of belonging, classroom engagement, and cognitive skills development were discovered. Efforts to improve student–faculty interaction will benefit all students, and improving those relationships for minoritized students will lead to more equitable outcomes in terms of classroom engagement and cognitive skills. Overall, the study offers promise because student–faculty interactions were strong predictors of multiple positive practices and outcomes.

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