RUNNING HEAD: "Pure" vs. "Applied" and Competencies

Does Majoring in a "Pure" Versus "Applied" Field Affect Knowledge Economy Competency Development? A Multilevel, Multi-institutional Test of Biglan

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Rationale for the Study

The United States' economy is changing. Once the harbinger of the world's products, the U.S. economy is increasingly grounded in knowledge-based products and services rather than tangible goods (International Monetary Fund [IMF], 2001; Samuelson, 2005). Whether moving from an agrarian to industrial economy or from an industrial to knowledge-based economy, the U.S. has been at the forefront (IMF; Samuelson). In large part, our higher education system has been a critical component in the United States' ability to lead the world through socioeconomic change. Compared to other nations and despite the conflicting goals of U.S. education (Labaree, 1997)[1], the United States has historically provided far greater educational access than any other country in the world. As such, when the economy has changed in a way that has required different skills, the populace has been educated to provide those skills (Samuelson).

Our position as an educational world leader, however, is now in question. The U.S. currently ranks 12th of all developed countries in postsecondary educational attainment (Organization of Economic Cooperation and Development [OECD], 2005). According to the U.S. Department of Education's (2006) recent report, "in tomorrow's world a nation's wealth will derive from its capacity to educate, attract, and retain citizens who are able to work smarter and learn faster – making educational achievement ever more important both for individuals and for society writ large" (p. ix).

We can think of achievement in terms of educational attainment—attaining the desired level of education—but we might also think of achievement as what students learn—what they are able to do—because of their education. Increasingly, employers identify the need for greater achievement in competencies related to success in the knowledge economy (American Council on Education, 2004; Conference Board, 2006; U.S. Department of Education, 2006).

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[1] Labaree posits that U.S. education faces conflicting goals of providing both public and private goods. These goals include educating students to: a.) engage as democratic citizens; b.) efficiently contribute to the nation's economy – both that serve the public good; and c.) claim the opportunity of social mobility that education provides – a private good.

In a global knowledge economy, college alumni will need to be actively, intellectually, and reflexively engaged in their work tasks (Bailey, 1995; Murnane & Levy, 1996; Zubroff, 1988), while working in decentralized team-based assignments with others whose perspectives, values, and cultural assumptions may differ (American Association of Colleges & Universities [AAC&U], 2004; Carnevale and Desrochers, 2002; Rychen & Salganik, 2001; 2003). The weight of the evidence (AAC&U; Carnevale and Desrochers; Carnevale, Gainer, & Meltzer, 1990; Evers, Rush, & Berdrow, 1998; O'Neil, Allred, & Baker, 1997, Rychen & Salganik) suggests that the following knowledge economy competencies are critical to success in the knowledge economy: cognitive problem solving, leading and communicating in groups, intercultural understanding, and lifelong reflective learning.

Interestingly, these knowledge economy competencies align closely with those that advocates of the traditional liberal arts and sciences disciplines have long held as key outcomes of a liberal education (Barker, 2000; DiConti, 2004; Pascarella, Wolniak, Seifert, Cruce, & Blaich, 2005). In their educational response to the changing American society, the Yale Report of 1828 noted that the traditional liberal arts curriculum was the best suited for providing both intellectual "discipline and the furniture of the mind" (Goodchild & Wechsler, 1989, p. 172). More recently, the Phi Beta Kappa Society called the *U.S. Secretary of Education's Commission on the Future of Higher Education* report (U.S. Department of Education, 2006) "seriously flawed by omission of the role of the liberal arts and sciences in sustaining the excellence of American higher education," further identifying "that broad undergraduate study in the liberal arts and sciences, by all students, conducted with rigor, is essential to the accomplishment of higher education's most important purposes" (Phi Beta Kappa Society, 2006).

Despite the similarities between competencies for the 21st century and hallmarks of a liberally educated person, one of the most noteworthy changes in American higher education in the last thirty years, has been the significant decline of students majoring in the traditional arts and science fields and the meteoric rise of occupationally-oriented, preprofessional programs (Adelman, 1999; Brint, 2002; Brint, Riddle, Turk-Bicakci, & Levy, 2005; Cohen, 1998). In light

of the shift in student majors, the question then arises as to what effect, if any, this contextual distinction of the college major (i.e., pure traditional arts and science disciplines compared to applied preprofessional programs) has on the development of knowledge economy competencies. Unless we accept the assumption that all college majors equally influence the development of knowledge economy competencies, college major and its pure-applied context are likely to influence the overall level of key competencies available to the nation's 21st century economy.

The primary aim of the present study was to improve our understanding of the relationships among individual alumni characteristics, the pure-applied context of the college major, and competencies associated with the knowledge economy. Thus, the following research questions guided this study.

(1) To what extent, if any, does college major influence knowledge economy competency development?

(2) In what way, if any, do individual alumnus/alumna characteristics influence knowledge economy competency development?

(3) How do contextual characteristics of the college major influence knowledge competency development among alumni? Specifically, does the pure (i.e., traditional liberal arts and sciences disciplines) versus applied (i.e., preprofessional) disciplinary distinction, advanced by Biglan (1973a, 1973b), explain differences in knowledge economy competency development?

Theoretical and Methodological Framework

The present study draws from Weidman's (1989) theory of undergraduate socialization. This theory identifies and operationalizes the social and interpersonal mechanisms that transmit and mediate the influences of the college environment. Weidman identified both academic and social dimensions as providing normative contexts within the collegiate experience. Within the academic dimension, the college major serves as one of the three formal structures that socializes

students to collegiate norms and more specifically, to the norms, goals, and expectations of their particular academic department/discipline.

The Biglan (1973a, 1973b) schema measures the attitudes and goals of various disciplines along three axes: paradigmatic perspectives (single- versus multi-paradigm), application of knowledge (pure versus applied), and connection to living entities (life versus non-life), building on the normative role played by individual disciplines. The traditional arts and science disciplines socialize students to value pure knowledge pursuits. In other words, socializing students to value inquiry and learning for its own sake defines the socialization of students to pure disciplines whereas preprofessional or applied majors socialize students to the occupational and practical application of knowledge (Paris, 2007). Thus, the Biglan pure-applied dimension serves as a theoretical contextual lens through which to view the effects of college major on knowledge economy competency development.

Because of the potential of the academic major to socialize students to the values of the discipline, students are often more similar to their peers in a major than to those in other majors (Smart, Feldman, & Ethington, 2000). Part of this similarity may be a function of disciplinary attributes, such as the norms, values, and interests reinforced and rewarded by the faculty. This "nesting" effect requires a methodological framework that holds data at two levels: an individual respondent level as well as at a group level (i.e., college major level). Thus, the present study employs hierarchical linear modeling, a method well-suited to handling multilevel data (Ethington, 1997; Hox, 2002; Luke, 2004; Raudenbush & Bryk, 2001).

Review of the Literature

Understanding the effects of college major on student learning outcomes has been the focus of a host of research on college impact (Feldman & Newcomb, 1969; Pascarella & Terenzini, 1991, 2005). Mixed evidence exists about the effects of academic subenvironments (e.g., college major) on student outcomes. In their synthesis of the impact of college on students, Feldman and Newcomb found college major contributed to frequent and substantial differences in the attitudes, values, and abilities of students both at matriculation to and commencement from

college. Pascarella and Terenzini (1991), in the first of their two seminal works, found college major to have little more than "a trivial net impact on one's general level of cognitive or intellectual outcomes" (p. 614) with little evidence of consistent changes attributable to college major in other areas of psychosocial growth, attitudes, or values.

The most recent installation of *How College Affects Students* (Pascarella & Terenzini, 2005) called for a modest revision of these conclusions. Consistent with the 1991 synthesis, the more recent evidence suggests that academic major does indeed lead to the development of different reasoning skills. Distinguishing between reasoning and critical thinking skills, Pascarella and Terenzini found the more recent evidence suggested exposure to natural science courses affected critical thinking skills positively although the effects of other types of coursework on critical thinking were inconclusive. In terms of psychosocial growth, attitudes, and values, in the aggregate, the evidence of major field effects on sociopolitical attitudes and values seems to be more a function of the values of the students choosing a discipline (i.e., selection effects) and the norms and values reinforced by the discipline than the actual subject matter of the academic field (Pascarella & Terenzini).

The Feldman and Newcomb (1969) and Pascarella and Terenzini (1991, 2005) syntheses reviewed the evidence with regard to college major effects on learning outcomes, in broad scale. A few studies have examined the effects of college major on several of the knowledge economy competencies examined in the present study (Astin, 1993; Evers, Rush, & Berdrow, 1998; Hayek & Kuh, 1998; Li, Long, & Simpson, 1999; Kwok, 2005; Pike & Killian, 2001; Seifert, Wolniak, & Pascarella, 2006; Smart, Feldman, & Ethington, 2000; Umbach & Porter, 2002).

Few of the previous research studies has used Biglan's (1973a, 1973b) pure-applied axis to frame their research question. Two studies (Hayek & Kuh, 1998; Seifert, Wolniak, and Pascarella, 2006) discussed their findings of college major on outcomes similar to the knowledge economy competencies relative to the major's distinction on the pure-applied axis.

Using cross-sectional data from three alumni cohorts (the mid 1970s, mid 80s, and mid 90s), Seifert, Wolniak, and Pascarella (2006) found, in general, graduates, who majored in the

traditional arts and science (i.e., pure disciplines) reported greater levels of professional competency development, compared to business majors (i.e., an applied major) whereas those who majored in other applied disciplines (e.g., computer science, engineering, health science) reported lower levels of professional competency development (similar to the cognitive problem solving and leading & communicating in groups competencies of the present study) than their business counterparts. With the exception of humanities graduates, those who majored in other pure disciplines also reported greater levels of development with regard to the cross-cultural cooperation and citizenship competency (closely aligned with the current study's intercultural effectiveness competency in the present study) compared to their business peers. Those who majored in applied majors again reported lower levels of development in this competency than those who majored in business. Although applied majors, in general, reported greater levels of technical competence and graduates from the humanities and social sciences reported lower levels than their peers who majored in business, those who majored in math and science reported greater levels of development in technical competence. Math and science alumni (one of the traditional divisions within the pure disciplines) reported greater levels of development on all of the three competencies compared to their business peers.

Using broad categories for college majors, Hayek and Kuh (1998) examined data from over 45,000 students from two cohorts (mid 1980s and mid 90s) who completed the College Student Experiences Questionnaire (CSEQ). They used items from the CSEQ to create the capacity for life-long learning index. This comprehensive index subsumed all of the competency facets of the present study and represented "a student's ability to 'learn to learn' and interact effectively with others in a complex information-based world" (Hayek & Kuh, p. 5). In ranking the adjusted means of college major for the capacity for life-long learning index, they found two of the most popular majors of the 1990s (i.e., computer science and business—both applied majors) ranked toward the bottom of the list, in ninth and tenth place out of eleven, respectively.

Similar to the findings of Seifert, Wolniak, and Pascarella (2006) in which students in math and the natural sciences reported greater levels of development on all competency

measures, Hayek and Kuh found both biological and physical sciences led the rankings, indicating that these pure majors had the highest scores on the life-long learning index. Despite the low scores for some of the applied majors, Hayek and Kuh noted the scores for the pure disciplines had decreased over the past decade, narrowing the gap with the applied fields (e.g., agriculture, business, computer science, education, engineering, and health-related fields).

Outside of the few studies that have used the pure-applied axis to discuss their findings, relatively little previous research (Kwok, 2005; Pike & Killian, 2001) has specifically examined the effects of the pure-applied axis on learning outcomes related to the knowledge economy competencies. Drawing on several studies that explored faculty attitudes and teaching orientations along the pure-applied axis, Pike and Killian hypothesized that because faculty in applied disciplines report greater interest in teaching and learning and devote more time to teaching than their colleagues in pure disciplines, students in applied disciplines would have more favorable perceptions of the college environment, be more involved, and report greater learning gains in terms of critical thinking, general education, and vocational preparation than their peers in pure disciplines.

Based on CSEQ data from approximately 600 students from a single research university, Pike and Killian (2001) found students' perceptions of the college environment, level of campus involvement, and integration of conversational content had positive effects on gains in critical thinking, general education, and vocational preparation. Contrary to their hypothesis, the effects did not vary across disciplinary groups. In other words, there was no significant effect of the college major's pure-applied distinction on gains in critical thinking. In sum, the data did not support their Biglan-based disciplinary hypothesis.

On the whole, the pure-applied, Biglan-related studies have tended to find no difference in developing knowledge economy competencies between the pure-applied distinction of the major. Both of the two studies that used the Biglan (1973a, 1973b) schema as a conceptual framework and the pure-applied distinction for their independent variable (Kwok, 2005; Pike & Killian, 2001) found no difference in critical thinking between pure and applied majors.

Although Kwok (2005), in his analysis of college students at seven Canadian universities, found students who majored in applied disciplines identified significantly greater teamwork skills than their peers in pure disciplines, the lack of statistical controls for individual student-level characteristics in Kwok's analyses is a great limitation. The dearth of significant and robust findings related to the Biglan axes might be a manifestation that too much variation exists within groups to find any consistent differences between groups (Pascarella & Terenzini, 1991, 2005).

Finally, individual student characteristics (e.g., gender, race/ethnicity, and parents' income) have a direct effect on competency development (Astin, 1993; Evers, Rush, & Berdrow, 1998; Pike & Killian, 2001; Seifert, Wolniak, & Pascarella, 2006). This suggests that who students are as well as how receptive they are to the educational experience (Pascarella, 2001) and to the socializing effects of the major (Pascarella & Terenzini, 1991, 2005) play a role in their competency development.

The present study addresses the limitations of previous research that has examined the effects of the pure-applied Biglan dimension on learning outcomes defined as competences necessary for success in the knowledge economy. By using a multi-institutional dataset, more stringent background controls, and an analytical technique that recognizes the nested nature of the data, this study adds to our understanding of the multilevel effects that individual characteristics and the pure-applied dimension of a college major have on alumni reports of developing competencies critical for success in the knowledge economy.

Methods

Data

These data were collected from alumni who completed the Alumni Outcomes Survey (AOS) (ACT, 1996) between January 1, 2000 and June 30, 2005. The AOS asked an extensive array of demographic information, including respondents' age, gender, racial/ethnic group, citizenship status, current employment status, level of education completed, level of education to which the respondent aspired at the time of high school completion and currently aspires. The survey also included a section of items regarding alumni perception of the degree to which their

college experiences influenced their attaining an array of educational outcomes (e.g., developing original ideas and/or products, defining and solving problems, etc).

The alumni survey data were then merged with data that these same alumni had provided in the ACT Student Information booklet (ACT, 2005) at the time they registered to take the ACT assessment while in high school. This additional wave of data collection provided a longitudinal retrospective of the sample in that the full dataset included respondents' high school experiences in addition to characteristics of their college and employment experiences. The longitudinal nature of the data enhanced the research design of this study in that it provided data on precollege educational aspirations and experiences as well as presocialization to the college major.

Sample

The longitudinal alumni sample consisted of 16,920 respondents of public and private colleges and universities from across the country. I restricted the sample to only those alumni who graduated from a four-year baccalaureate granting institution, listed a valid academic major, and who had complete information on the dependent measures. After these restrictions and missing listwise elimination, the sample consisted of 14,069 alumni. I provide complete descriptive information for the analytic sample on all variables in Table 1.

<Insert Table 1 about here>

Variables

Guided by the past research on competencies for the knowledge economy (AAC&U, 2004; Carnevale and Desrochers, 2002; Carnevale, Gainer, & Meltzer, 1990; Cope & Kalantzis, 1997; Evers, Rush, & Berdrow, 1998; Grubb & Lazerson, 2005; Kearn, 2001; O'Neil, Allred, & Baker, 1997; Rychen & Salganik, 2001, 2003; Sinclair, 1997; Stark & Lowther, 1989; U.S. Department of Labor, 1991), I factor analyzed the AOS self-report items of the impact of college on a host of educational outcomes. Four factors emerged, measuring the constructs of cognitive problem solving ($\alpha = .730$), leading and communicating in groups ($\alpha = .768$), intercultural

understanding (α = .799), and lifelong learning (α = .726). I present the constituent items and factor loadings in Table 2.

I chose to create factor scores for each of the dependent variables. A factor score is the sum of all products between the cases's standardized score on an item and the factor loading for that item within the factor. Factor scores are standardized variables with a mean of zero and a standard deviation of one. A benefit of using factor scores for the dependent variables is that it is a weighted measure that proportionately weights the constituent items within the factor based on their factor loadings.

<Insert Table 2 about here>

The independent variables in the present study comprised two levels and several conceptual sets. Level-1 variables were those existing at the individual respondent level, while level-2 variables were those that described the Biglan (1973a, 1973b) pure-applied context of the major. Based on the conceptual framework used in a host of studies of college impact (Astin, 1977; Chickering, 1969; Pascarella, 1985; Weidman, 1989), I included general sets of level-1 variables to incrementally isolate the unique effects of college impact. These sets, considered causally antecedent to the outcome, included student sociodemographic and precollege characteristics and measures of the college experience.

In the block of sociodemographic and precollege experience variables, I included: gender (women served as the reference category); race/ethnicity (White served as the reference category); standardized value of parents' income; perception of needing help in college in reading, writing, and math (not needing help was the reference category); standardized value of academic ability; educational aspirations while in high school; standardized measure of high school involvement (α = .60) (see Table 3); evaluation of the adequacy of their high school education; certainty of their college major; and the degree to which the college major influenced their college choice. Recognizing Pascarella and Terenzini's (1991, 2005) statement that the effects of college major on learning outcomes, particularly psycho-social outcomes, are largely confounded by the values and interests that students bring with them to college, the latter two

variables were included to take into account the degree to which students had been presocialized to the major and the norms and values of its distinction as a pure or an applied discipline.

<Insert Table 3 about here>

The block of college experience variables included: standardized value of college academic ability; standardized value from a scaled measure of co-curricular civic activities and organizations involvement (i.e., college activities/organizations: service, environmental, political, cultural, and community) (α = .724); standardized valued from a scaled measure of respondents' perceptions of the scholarly emphasis of the collegiate environment (α=.763) (see Table 4); and self-reported quality of the major.

<Insert Table 4 about here>

The alumni's college major was an important variable in these analyses in that it was the variable from which I partitioned the variance of the knowledge economy competencies into their constituent parts of between-group and within-group variance. In light of the preprofessional trend in college major choice, the level-2 contextual variable of interest was the pure-applied Biglan axis, with applied (i.e., preprofessional programs) serving as the reference group. This allowed me to see what effect, if any, majoring in a pure (i.e., traditional arts and sciences) discipline had on knowledge economy competency development, net of individual respondent characteristics.

Analyses

The research questions, as previously articulated, implicitly hold the data to be multilevel with alumni nested within academic majors. HLM, as opposed to Ordinary Least Squares (OLS) regression, is well-suited to analyze data at more than one level in that it allows simultaneous estimation of equations at both the individual and disciplinary level (Ethington, 1997; Hox, 2002; Luke, 2004; Raudenbush & Bryk, 2001). I used hierarchical linear modeling (HLM) to simultaneously examine the effects of individual alumni characteristics, and more centrally, the pure-applied distinction of the academic major on the development of knowledge economy competencies.

The multi-level nature of "school effects" research has long plagued educational researchers (Raudenbush & Bryk, 2001). College impact researchers have struggled with which unit to use for analysis: the individual student unit or the individual college/university as the group unit (Pascarella & Terenzini, 1991). Ethington (1997) noted that many educational researchers have chosen to use students as their unit of analysis, simply assigning institutional measures to each student within an institution. This example of disaggregating higher order variables (i.e., group-level variables—in the case of the present study, variables related to academic discipline) to the individual student level violates one of the Ordinary Least Squares assumptions of independence of observations and yields correlated errors and misestimates standard errors (Ethington; Hox, 2002; Luke, 2004). Misestimated standard errors can lead to finding significant relationships were none exist (see Bryk & Raudenbush, 1992).

The other approach to the unit of analysis problem is to aggregate student level data to the institutional level. This leads to an aggregation bias problem in that relationships in the aggregate are typically much stronger and often change their meaning when aggregated (Ethington, 1997; Hox, 2002). Ethington provided a useful example. Student's socioeconomic background is a common measure included in educational attainment research in that it serves as a measure of social class and a proxy for the educational and financial resources of the student's family. When researchers aggregate the socioeconomic status of all students at an institution, the result represents a normative institutional environment and can impact individual student educational attainment over and beyond the effect of the individual's socioeconomic background.

Multilevel modeling resolves these problems by simultaneously decomposing the relationship between variables into their constituent student-level and group-level components (Raudenbush & Bryk, 2001). As such, the aggregation bias problem is no longer an issue. The dependence among individuals within groups, resulting in correlated errors, and misestimating standard errors ceases to be a problem because the statistical model incorporates a unique

random effect for each organizational unit (academic major) and accounts for the variability of these random effects when estimating standard errors (Ethington, 1997).

I conducted the multilevel analyses for this study in several steps. First, I created a model with no predictor variables. In this one-way ANOVA, often called the null model, I partitioned the variance in the dependent variable. Equation 1 displays the null model.

$$Y_{ij} = \beta_{0j} + r_{ij} \quad (1)$$

where Y_{ij} is the dependent variable, β_{0j} is the mean of the academic major for a specific competency, and r_{ij} is the deviation from the academic major's mean for alumnus/alumna *i* in major *j*. The implied academic major-level model was specified as:

$$\beta_{0j} = \gamma_{00} + u_{0j} \quad (1a)$$

where β_{0j} is the competency mean, γ_{00} is the grand-mean of the competency across all academic majors and u_{0j} is the deviation from the grand mean for academic major *j*. Estimating the null model allowed me to compute the intra-class correlation coefficient (ICC) which measures the proportion of variance in the dependent measure within- and between academic majors (Kreft & DeLeeuw, 1998). This is a critical baseline in that any reduction in component variance in subsequent models represents that amount of component variance explained by the additional variables added to the regression specification.

In the second step of the modeling process, I created the within-major models (i.e., the level-1 or individual-level models). As previously discussed, the level-1 model consisted of two blocks of variables: sociodemographic and precollege experiences as well as college experience variables. Equation 2 shows the first block of the level-1 model[2]. The second block of variables was simply added to this regression equation.

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[2] In the level-1 model, the predictor variables "HS_HelpRead" and "HS_HelpWrite" were only entered into the model for the "Leading and Communicating in Groups" competency while "HelpMath" was only entered into the model for the "Cognitive Problem Solving" competency. I only entered the quadratic term for high school GPA in the preliminary analyses. I did not find it to be significant in predicting knowledge economy competencies and I removed it from the models.

$$Y_{ij} = \beta_{0j} + \beta_1(\text{Male}) + \beta_2(\text{AfAm}) + \beta_3(\text{Latino}) + \beta_4(\text{AsianAm})$$
$$+\beta_5(\text{NatAm}) + \beta_6(\text{RaceOther}) + \beta_7(\text{RaceNone}) + \beta_8(\text{ZHS\_FamInc}) + \beta_9(\text{HS\_HelpRead})$$
$$+\beta_{10}(\text{HS\_HelpWrite}) + \beta_{11}(\text{HS\_HelpMath}) + \beta_{12}(\text{ZHS\_GPA}) + \beta_{13}(\text{ZHS\_GPASq})$$
$$+\beta_{14}(\text{ZHS\_Involve}) + \beta_{15}(\text{LTBach}) + \beta_{16}(\text{GradDeg}) + \beta_{17}(\text{LoAvQual}) + \beta_{18}(\text{AvQual})$$
$$+\beta_{19}(\text{ExQual})\ \beta_{20}(\text{MNSure}) + \beta_{21}(\text{MVSure}) + \beta_{22}(\text{MMImp}) + \beta_{23}(\text{MHImp}) + r_{ij} \qquad (2)$$

In Equation 2, the *j* subscripts indicate academic majors whereas the *i* subscripts indicate individual alumnus/alumna within *j* major. In this model, I allowed only the intercept to vary across academic discipline and I considered the intercept to be a function of the grand mean across all disciplines plus random error for each discipline. In these models, the individual-level coefficients were "fixed" meaning that their effects were constrained to be the same across all academic majors (Bryk & Raudenbush, 1992; Raudenbush & Bryk, 2001). Additionally, all individual-level variables were centered on their grand means. This allows the intercept to be interpreted as an adjusted estimate of the outcome or the expected outcome value for "average" graduates – those who have mean characteristics (Bryk & Raudenbush; Raudenbush & Bryk). Any reduction in the within-major variance represented the variance explained by the alumni-level variables (Ethington, 1997).

The final step in the modeling process specified the variable included in the group-level (i.e., the level-2) model, specifically the pure-applied distinction of the Biglan schema. Equation 3 show the level-2 model, which I added separately to the previous equations.

$$\text{Biglan (Pure vs. Applied axis):}\ \ \beta_{0j} = \gamma_{00} + \gamma_{01}(\text{TradLA\_m}) + u_{oj} \qquad (3)$$

This was a random-intercept model since I allowed the intercept to vary relative to contextual characteristics of the academic major. Specifically, the intercept was a function of the grand mean across all academic majors on the competency under investigation as well as the group-level variable identified in Equations 3 plus random error of the specific major. Any significant

reduction in the between-major variance was a function of the explanatory power of the group-level variables (Ethington, 1997).

Results

Does college major influence knowledge economy competency development?

In response to research question 1, Table 5 shows a significant amount of the variance in knowledge economy competency existed between majors. The amount of between-major variance, relative to total variance, in the knowledge economy competencies ranged from 2.7 to 4.3%, thus demonstrating that the data were indeed "nested". Although this may seem like an inconsequential amount of between-major variance, others have asserted that higher education research regularly only explains 30% of the total variance in a dependent measure and thus less than 5% of between-major variance is not insubstantial (Porter & Swing, 2006).

<Insert Table 5 about here>

Do individual characteristics influence knowledge economy competency development?

The second research question examined the extent to which individual-level characteristics influenced knowledge economy competency development. Having decomposed the total variance of knowledge economy competencies into between-major variance and within-major variance, this research question explains the within-major variance (i.e., the individual-level variance) using alumni characteristics as predictor variables. I regressed the knowledge economy competencies on two sets of variables to investigate what relationship, if any, these alumni attributes had on knowledge economy competency development. In the first model, I regressed the knowledge economy competencies on alumni sociodemographic characteristics and pre-college experiences. In the second model, I added a block of variables representing alumni college experiences. I provide the coefficients for the full level-1 models for the four knowledge economy competencies in Table 6. Coefficients can be interpreted as effect sizes because the dependent variable is a standardized factor score. All independent variables are a one-unit metric: either a one-unit categorical increase or a standardized-unit increase.

<insert Table 6 about here>

In the full level-1 models, race/ethnicity and gender were the most consistent and strongest predictors of knowledge competency development among the sociodemographic and pre-college experience variables. Net of college major and a host of confounding factors, Latino and Native American alumni (compared to White alumni) reported greater development in lifelong reflective learning while Asian American alumni reported greater cognitive problem solving development. African American alumni reported greater levels of development across all of the knowledge economy competencies than did their White counterparts. Male alumni reported lower levels of college impact than their female colleagues on development in three of the four knowledge economy competencies: leading and communicating in groups, lifelong reflective learning, and intercultural understanding. Male and female alumni did not differ in their reports of college impact on the development of cognitive problem solving.

Alumni education aspirations during high school were the only precollege experience that had consistent effects with absolute value magnitudes of .07 SD or greater. Alumni who at the time of high school aspired to less than a bachelor's degree reported lower levels of college impact on knowledge economy competency development than their peers who aspired to a bachelor's degree. These effects ranged from -.07 SD for lifelong reflective learning to -.16 SD for leading and communicating in groups.

Among the college experience variables, alumni co-curricular civic involvement and alumni perceptions of the institution's scholarly emphasis were the most consistent and positive predictors of college impact on knowledge economy competency development. Although the effects of co-curricular civic involvement were fairly small, they were consistent across all of the competencies. Alumni perception of the institution's scholarly emphasis was the strongest predictor of college impact on the development of knowledge economy competencies of all of the level-1 variables.

Do contextual characteristics of the major influence competency development?

The third research question focused on explaining the portion of the variance that existed between majors. To explain the between-major variance, I entered a variable that measured

whether the major was pure versus applied. I present the coefficients for the Biglan contextual model at the top of Table 6.

In terms of predicting knowledge economy competency development, Table 6 shows that alumni from pure academic majors reported greater impact of college on the their development in of lifelong reflective learning but lower levels of development in leading and communicating in groups and cognitive problem solving, controlling for all other confounding influences. I found no difference in the development of intercultural understanding between alumni who majored in pure versus applied disciplines.

Discussion

In a changing economy, in which the competencies for success differ in marked ways from those of the past and in which there has been an exponential increase in students choosing to major in occupationally-oriented fields, it seemed prudent to examine the role that college major, and more specifically its context, plays in the development of competencies that business, government, and educational stakeholders have identified as crucial for success in the knowledge economy. From this framework, I used multi-level analyses techniques to examine the unique effects of individual alumna/alumnus characteristics and the pure-applied contextual characteristic of the college major, particularly as it relates to students' socialization to an academic discipline, on the development of knowledge economy competencies. In this section, I separately discuss the results of the level-1 and level-2 findings. I then suggest implications for theoretically framing college major. I conclude by identifying limitations of the study and possible avenues for future research.

Level-1: Sociodemographic characteristics

The race and ethnicity findings provide evidence that, apart from the types of majors that alumni select, alumni of color report the impact of college on their development of knowledge economy competencies differently than their White peers. The results from the present study suggest that, on average, alumni of color report greater college impact than White alumni, all else equal. Although debating the extent to which alumni of color feel welcome and supported on

college campuses is beyond the scope of this research, these findings call into question the assertion (see Allen, 1987; Sedlacek, 1999; Wasson, 1990) that the college milieu is so "chilly" for alumni of color that college impact on learning outcomes is inhibited.

These findings highlight a potential disconnect between self-reports of college impact and objective attainment. The present results find alumni of color reported higher levels of impact on their learning and development. However, research from Flowers and Pascarella (2003), comparing the cognitive development of African American and White students, found that controlling for precollege and institutional characteristics as well as academic experiences, African American students reported lower levels of development on objectively-measured cognitive outcomes than their White peers. It is possible that the race/ethnicity findings of the present study are an artifact of students of color using a different baseline from which to report the impact of college on knowledge economy competency development than their White peers.

Gender (i.e., being male) had a negative influence on the development of knowledge economy competencies. With the exception of cognitive problem solving, male alumni reported significantly lower levels of knowledge economy competency development than their female peers. The nonsignificant finding of gender on cognitive problem solving adds yet more complexity to the already mixed results from the extant literature. The present findings raise an important question in terms of male students getting the most out of college. Considering that male students are matriculating at four-year institutions at a lower rate than female students (NCES, 2005), it becomes increasingly important to identify practices and conditions of the overall institutional environment as well as contextual characteristics of subenvironments that contribute positively to knowledge economy competency development for male students.

These sociodemographic findings, regardless of the differential baseline that may have been employed by alumni for reporting impacts, is cause for college and university communities to consider in what way they could alter their programs, policies, and pedagogies to more effectively engage *all* students in developing competencies necessary for success in the knowledge economy. The inconsistency of results from the literature with regard to

race/ethnicity and gender effects on the development of knowledge economy competencies suggests that colleges and universities would best serve student learning by attracting as large and diverse of student pool as possible to engage in opportunities that foster such development.

Engaging the most diverse pool of students may mean developing targeted marketing strategies to reach different subgroups of the student population. What may attract women to a program geared toward fostering lifelong reflective learning may be quite different from that which would attract men to the same program. Targeted marketing strategies capitalize on reaching out to students in ways that resonate for them and includes both passive (i.e., standard print and audio forms of marketing) as well as direct marketing (i.e., directly inviting students to engage in a program). Learning to communicate similar messages in different contexts to different audiences is itself related to one of the knowledge economy competencies. University communities (both faculty and student affairs staff) would likely serve students better by nurturing their own development in this critical area.

Level-1: College experiences

Of the individual-level characteristics, the experiences that alumni had while in college were more predictive of knowledge economy competency development than their sociodemographic characteristics or pre-college experiences. Compared to within-major variance explained by the this first block of variables entered into the models, the college experience variables explained up to 20% more variance across knowledge economy competencies. The co-curricular civic involvement and scholarly emphasis of institution variables were consistent positive predictors of alumni reports of college impact on the development of all knowledge economy competencies.

A large body of research has found co-curricular involvement to positively influence student learning (Astin, 1984; Foubert & Grainger, 2006; Kuh, Kinzie, Schuh, Whitt, & Associates, 2005; Kuh, Schuh, Whitt, & Associates, 1991; Pascarella & Terenzini, 1991, 2005; Terenzini, Pascarella, & Blimling, 1996). The present findings further support this body of literature but also provide specific focus on the value of involvement in civic-oriented activities

and organizations. As alumni increased their levels of co-curricular civic involvement, they reported significantly greater levels of college impact on their development across the breadth of knowledge economy competencies.

The nature of this involvement is important to note because I did not include all types of co-curricular involvement in the scaled measure but purposefully created a measure that included only those activities/organizations that theoretically contribute to broader civic goals (i.e., service, environmental, political, cultural, and community goals). In this regard, these results provide support for the body of research that has detailed the positive effects of community service and volunteerism (Astin & Sax, 1998; Astin, Sax, and Avalos, 1999; Astin, Vogelsang, Ikeda, & Yee, 2000). The significant positive effects of co-curricular civic involvement on the development of knowledge economy competencies provides additional evidence to Kezar's (2002) argument that community service learning contributes to learning outcomes, particularly when those examined are beyond the logical and linguistic domains.

Overwhelmingly, alumni perception of their institution's intellectual and scholarly emphasis was the most salient predictor of knowledge economy competency development. This scaled variable, which measured alumni ratings of the overall academic program and their perception of the institution's encouragement and support of academic success, had the largest consistent positive effects of the alumni characteristics across all of the knowledge economy competencies. These results are in line with the body of research on student success and student engagement, which advances that students who are challenged and held to high expectations for academic excellence report the highest level of development on a host of outcomes (Astin, 1993; Chickering & Reisser, 1993; Cruce, Wolniak, Seifert, Pascarella, & Blaich, 2005; Kuh, Kinzie, Schuh, Whitt, & Associates, 2005; Kuh, Schuh, Whitt, & Associates, 1991; Pascarella & Terenzini, 1991, 2005).

These findings also provide additional evidence to support the notion that the most influential predictor of alumni development in areas critical for success in the knowledge economy lies within the purview of college and university communities to change. In other

words, what makes the most difference in alumni knowledge economy competency development is something that faculty and student affairs professionals can directly influence. If a university community is serious about fostering knowledge economy competency development among their students, these findings suggest that a sincere and thorough institutional effort to change the campus discourse to one that is more intellectually stimulating and scholarly-focused, pays dividends.

Level-2: Biglan Pure-Applied Axis

Many proponents of liberal arts education declare the traditional arts and science disciplines as the best way to teach students broad habits of the mind. One needs to look no further than the historic Yale Report of 1828 (see Goodchild & Wechsler, 1989) to see the American root of this assertion. Because the knowledge economy competencies defined in the present study are not narrow subject-matter measures but broad constructs with both historical grounding and present day relevance, I investigated the traditional arts and sciences claim of superiority with regard to instilling the broad habits of the mind critical for success in the 21st century economy.

I found mixed effects of majoring in one of the traditional arts and science disciplines, compared to occupationally-oriented, preprofessional majors (i.e., pure vs. applied), on knowledge economy competency development. Although alumni in the pure disciplines reported greater college impact in their development of lifelong reflective learning, they were disadvantaged in development of both leading and communicating in groups and cognitive problem solving competencies compared to their peers who majored in applied fields. Those in pure majors also did not differ in developing intercultural understanding from their counterparts in applied fields.

In terms of using the pure-applied axis of Biglan (1973a, 1973b) as a conceptual framework, clearly a problem exists in the efficacy of a framework if its measure's effects are inconsistent in both their significance and direction. Thus, the findings from the present study

provide evidence to suggest that the Biglan schema lacks robustness as a conceptual framework for college impact studies examining student learning outcomes.

The mixed nature of the results (one positive, two negative, one with no difference), as well as previous research, call to question those who assert that the pure disciplines, as the bedrock for liberal arts education, are best suited to educate students in developing broad habits of the mind. Given that the knowledge economy competencies of the present study parallel those advanced by the AAC&U (2004)—one of the largest organizations promoting liberal education in the United States—the present findings give cause to reconsider the rhetoric. These findings suggest it matters little whether the major is affiliated with the pure disciplines in terms of developing broad habits of the mind, in this study defined as knowledge economy competencies. As evidenced by the large effect that scholarly emphasis had on competency development, what seems to matter is what the institution, particularly faculty, emphasize and what they ask students to do,

These results provide further support for the liberal arts emphasis construct introduced by Pascarella and colleagues (2005). Essentially, the liberal arts emphasis constitutes those practices and conditions that promote liberal arts outcomes (Center of Inquiry in the Liberal Arts at Wabash College, 2004), of which the knowledge economy competencies overlap significantly. In this regard, the results suggest that the extent to which agents of the academic major (i.e., the faculty) emphasize and foster practices and conditions associated with knowledge economy competency development matters more than the distinction (i.e., pure versus applied) of the academic field. It appears that developing broad habits of the mind is less determined by the college major's Biglan distinction but the institutional ethos that promotes knowledge economy competency development.

Limitations and Future Research

Although the present study provided insight into the unique effects that the pure-applied distinction has separate from individual characteristics, the inherent limitations of secondary data analysis provide many different avenues for future research. The main limitations of this study

include the self-reported nature of college impact, the cross-sectional design, the lack of in-class practice and pedagogical measures, the lack of robust measures of co-curricular civic involvement, and the analytic decision to use a two-level versus three-level or cross-classified method.

The Wabash National Study of Liberal Arts Education [WNSLAE] is currently collecting multi-institutional data that addresses virtually all of the limitations detailed in the present study. The longitudinal panel design uses objective measures to identify student growth during college along many of the knowledge economy competencies including cognitive problem solving, leadership, and intercultural understanding. These objective measures, administered in a pretest/posttest format, alleviate the limitations of the cross-sectional self-reports existing in the current study. Moreover, these measures retain the delineation of the competencies rather than collapsing them into one omnibus measure. As such, future research will be able to examine the contextual characteristics of the college major across individual competencies in their multiple facets.

In addition to the objectively measured dependent variables, WNSLAE is using both the National Study of Student Engagement [NSSE] and an additional college experiences questionnaire to get a sense of students' experiences both in- and out-of-the-classroom. These measures include students' experiences of college teaching; the interaction they have with faculty, student affairs staff, and peers; the extent to which they feel challenged academically; and to what extent they engage in co-curricular experiences such as living learning communities, clubs and organizations, intramural sports, and community service to name a few. The depth of these measures will enable future research to model the full collegiate environment at both the individual student level as well as in terms of contextual characteristics of the academic major.

Overall, the WNSLAE has the promise to remedy the limitations in the present study and provide further understanding regarding the effects of college major and its context on the development of knowledge economy competencies. Considering the U.S. Department of Education (2006) has recently advanced, "we want a higher education system that gives

Americans the workplace skills they need to adapt to a rapidly changing economy" (p. ix), it is imperative the higher education community develop greater understanding as to what it is about the college milieu, and particularly one of its primary academic socializing forces – the college major – that contributes to alumni development of competencies necessary for success in today's and tomorrow's economy.

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Table 1. Descriptive Statistics of All Variables in Analyses

Alumni Level Variables (N=14,069)				
	Mean	SD	Minimum	Maximum
Sociodemographic and Precollege Experiences				
African American	0.033	0.18	0	1
Native American	0.070	0.08	0	1
White (reference group)	0.907	0.29	0	1
Latino	0.020	0.14	0	1
Asian American	0.011	0.10	0	1
Other Race	0.005	0.07	0	1
No response for race	0.018	0.13	0	1
Male	0.310	0.46	0	1
HS Family Income	61,415	27,813	17,500	110,000
HS Family Income (standardized)	0	1	-1.58	1.75
Need help in reading	0.21	0.41	0	1
Need help in writing	0.27	0.44	0	1
Need help in math	0.32	0.47	0	1
High School (HS) GPA	3.37	0.51	1.13	4
High School (HS) GPA (std.)	0	1	-4.42	1.23
Ed aspirations: below BA	0.07	0.25	0	1
Ed aspirations: BA (ref.)	0.54	0.50	0	1
Ed aspirations: grad degree	0.39	0.49	0	1
HS Involvement (std.)	0	1	-1.03	4.53
HS quality: below average	0.11	0.31	0	1
HS quality: average	0.22	0.41	0	1
HS quality: good (ref.)	0.45	0.50	0	1
HS quality: excellent	0.22	0.41	0	1
College major: not sure	0.25	0.43	0	1
College major: fairly sure (ref.)	0.43	0.50	0	1
College major: very sure	0.32	0.47	0	1
Major: low importance (ref.)	0.63	0.48	0	1
Major: moderately important	0.17	0.38	0	1
Major: highly important	0.19	0.39	0	1
College Experiences				
College GPA	3.28	0.44	1.75	3.75
College GPA (standardized)	0	1	-3.49	1.07
Co-Curricular Civic Involvement	0	1	-1.43	3.51
College's scholarly emphasis	0	1	-4.79	1.53
Major quality: no opinion	0.1	0.3	0	1
Major quality: dissatisfied	0.07	0.25	0	1
Major quality: satisfied (ref.)	0.41	0.49	0	1
Major quality: very satisfied	0.43	0.49	0	1

Table 1., continued.

Alumni-level Variables, cont.				
	Mean	SD	Minimum	Maximum
Contextual Characteristics of Major				
"Pure" disciplines	.319	.46	0	1
Artistic majors	.070	.26	0	1
Alumni Outcomes				
Leading and Communicating in Groups	0	1	-3.97	1.24
Lifelong Reflective Learning	0	1	-3.53	1.57
Intercultural Understanding	0	1	-2.78	1.36
Cognitive Problem Solving	0	1	-3.67	1.71
Academic Major-level Variables (N=192)				
Biglan distinction				
"Pure" disciplines	0.30	0.46	0	1

Table 2. Dependent Variables with Constituent Items

Alumni self-reports of college impact on:	Reliability	Factor Loading
Cognitive problem solving	α = .730	
1. Defining and solving problems		0.535
2. Accessing and using a variety of information sources		0.600
3. Learning about existing and emerging career options		0.573
4. Understanding the interaction of human beings and the environment		0.522
5. Analyzing and drawing conclusions from various types of data		0.773
Leading and communicating in groups	α = .768	
1. Recognizing and using effective verbal communication skills		0.729
2. Developing and using effective leadership skills		0.643
3. Recognizing and using effective written communication skills		0.627
4. Working cooperatively in groups; working as a team member		0.648
Intercultural understanding	α = .799	
1. Getting along with people from various cultures, races, backgrounds, etc.		0.807
2. Understanding and appreciating cultural and ethnic differences between people		0.807
3. Getting along with people whose attitudes and opinions are different from mine		0.575
Lifelong, reflective learning	α = .726	
1. Developing original ideas and/or products		0.637
2. Thinking objectively about beliefs, attitudes, and values		0.718
3. Making and exercising a lifelong commitment to learning		0.622
4. Living my personal and professional life according to my own standard/ethic		0.695

Table 3. Constituent Items of High School Involvement Scale

High School Involvement Scale (alpha = .60)	
1.	Wrote an independent paper on a scientific topic which received the highest possible grade given in my school
2.	Performed an independent scientific experiment (not as part of a course).
3.	Won a prize or award (of any kind) for scientific work or study
4.	Participated in school publications
5.	Participated in debate
6.	Entered a school speech or debate contest
7.	Worked on staff of school paper or yearbook
8.	Participate in student government
9.	Actively campaigned to elect myself or other to school office
10.	Supervised the work of others

Table 4. Constituent Items for Scholarly Emphasis Scale

Scholarly Emphasis Scale

1. Rating of overall quality of academic programs (Response set: 1-5 Likert scale)
2. Satisfaction with overall quality of instruction (Response set: very dissatisfied to very satisfied)
3. Satisfaction with preparation for further academic study (Response set: very dissatisfied to very satisfied)
4. Opinion regarding whether overall, the school had an intellectually stimulating atmosphere (Response set: strongly disagree to strongly agree)
5. Opinion regarding whether academic success was encouraged and supported at this school (Response set: strongly disagree to strongly agree)

Table 5. Null Models: Partitioning Variance in Knowledge Economy Competencies

	Leading and Communicating in Groups	**Lifelong Reflective Learning**	**Intercultural Understanding**	**Cognitive Problem Solving**
Null models				
Variance components				
Between-majors (intercept)	0.039	0.034	0.043	0.027
Within-majors	0.957	0.959	0.953	0.964
Reliabilities	0.537	0.512	0.553	0.464
ICC	0.039	0.035	0.043	0.027

Table 6. Multilevel Effects of Individual Alumni Characteristics and Biglan Distinction on Development of Knowledge Economy Competencies

		Cognitive Problem Solving		**Leading and Communicating in Groups**		**Lifelong Learning**		**Intercultural Understanding**	
	Type of Unit Change	B		B		B		B	
Constant		-0.010		-0.011		-0.003		-0.012	
"Pure" vs "Applied" Biglan Distinction									
Pure Disciplines	0→1	-0.159	***	-0.222	***	0.095	**	0.016	
Sociodemographic and Precollege Experiences									
White (reference group)									
African American	0→1	0.320	***	0.313	***	0.113	*	0.160	***
Native American	0→1	-0.038		0.057		0.192	*	-0.078	
Latino	0→1	-0.026		0.040		0.182	***	0.054	
Asian American	0→1	0.193	**	-0.056		0.124		0.123	
Other Race	0→1	-0.034		-0.231	†	-0.157		-0.034	
No response for race	0→1	-0.083		-0.131	*	-0.045		-0.127	*
Male	0→1	-0.029	†	-0.172	***	-0.118	***	-0.180	***
HS Family Income	Δ SD	-0.034	***			-0.014	*	-0.035	***
Need help in math		0.021		-0.019					
Need help in reading				0.014					
Need help in writing				-0.026	**				
High School (HS) GPA	Δ SD	-0.026	**	-0.160	***	-0.043	***	-0.024	**
Ed aspirations: below BA	0→1	-0.127	***			-0.072	*	-0.113	**
Ed aspirations: BA (ref.)				-0.051	**				
Ed aspirations: grad degree	0→1	-0.065	***	-0.002		-0.029	†	-0.074	***
HS Involvement	Δ SD	-0.027	***	0.027		-0.001		-0.011	
HS quality: below average	0→1	0.026		0.042	*	0.041	†	-0.009	
HS quality: average	0→1	0.024				0.060	**	0.069	**
HS quality: good (ref.)									
HS quality: excellent	0→1	0.023		0.064	**	0.053	**	0.028	
College major: not sure	0→1	-0.029		0.011		-0.008		-0.003	
College major: fairly sure (ref.)									
College major: very sure	0→1	0.045	*	0.043	*	0.053	**	0.067	***

Table 6., continued.

		Cognitive Problem Solving		Leading and Communicating in Groups		Lifelong Learning		Intercultural Understanding	
Major: low importance (ref.)									
Major: moderately important	0→1	0.000		0.024		-0.008		0.014	
Major: highly important	0→1	-0.012		0.000		-0.001		0.024	
College Experiences									
GPA	Δ SD	-0.044	***	-0.018	*	0.017	†	-0.042	***
Co-curricular Involvement	Δ SD	0.073	***	0.092	***	0.099	***	0.094	***
College's scholarly emphasis	Δ SD	0.376	***	0.384	***	0.419	***	0.307	***
Major quality: no opinion	0→1	0.047		0.052	†	0.117	***	0.073	*
Major quality: dissatisfied	0→1	-0.269	***	-0.184	***	-0.106	**	-0.072	†
Major quality: satisfied (ref.)									
Major quality: very satisfied	0→1	0.149	***	0.118	***	0.119	***	0.021	
Variance Components									
Between-majors (intercept)		0.025		0.024		0.018		0.025	
Between-majors explained		(5%)		(39%)		(47%)		(41%)	
Within-majors		0.754		0.746		0.733		0.835	
Within-majors explained		(22%)		(22%)		(24%)		(12%)	
Reliabilities									
Intercept		0.500		0.491		0.444		0.478	

† $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.001$