Hyper-Specialization and Hypo-Specialization: Double Majoring and The Concentration Of Academic Knowledge

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ABSTRACT: In this article, we examine the relationship between academic specialization and student exposure to a range of academic domains of knowledge. Specifically, we use a concentration measure—the Herfindahl-Hirschman index—to investigate if students who choose single majors (i.e., specialists), double majors in the same disciplinary cluster (i.e., hyper-specialists), or double majors in different disciplinary clusters (i.e., hypo-specialists) are more or less concentrated in liberal arts domains of knowledge. Our results, based on an analysis of 240 undergraduate transcripts, indicates that hyper-specialization (particularly in both the social and physical sciences) significantly concentrates student learning in some of the nine domains of knowledge most postsecondary institutions consider to be the intellectual core of an undergraduate education. Conversely, hypo-specialization (broadly, but particularly in the physical sciences) leads to more breadth; students spread their courses more evenly across the nine domains.

A recent Pew Research Center (2011) study showed that 52% of college graduates believe the main purpose of college is to help individuals grow personally and intellectually.[1] In a survey of nearly 500 chief academic officers, researchers uncovered six primary purposes for general education curricula created to facilitate this kind of growth (Smith 1993). Of these, the two considered the highest priorities were developing critical thinking and other skills (instrumentalism) and exposing students to a broad range of subject matter (breadth). In many ways, these objectives are not only fundamental to the goals of any specific general education system, but they are commonly perceived goals of baccalaureate level training more generally. The latter of these aims—breadth—sits at the heart of creation of the type of Renaissance student many associate with a baccalaureate degree and the intellectual growth it fosters.

According to Goyette and Mullen, "liberal learning values breadth of knowledge over narrow specialization and holds an appreciation of learning for its own sake rather than utilitarian ends" (2006:498). That said, a liberal education—particularly one characterized by exposure to a multiple domains of knowledge—can have utilitarian ends as well. Kanter's (1983) prescription for an "American corporate Renaissance" focuses on innovators who are "broader-gauged, more able to move across specialist boundaries, comfortable working in teams that may include many disciplines, [and] knowledgeable about how to manage ambiguous assignments and webs of interdependencies. In short, Renaissance people . . . encouraged by a strong, affordable educational system that combats narrow vocationalism and permits people the luxury of studying a variety of fields before becoming too specialized" (368).

The root of innovation—creativity—has long been associated with knowledge that spans different subject areas and fields of inquiry. Root-Bernstein (1995, 2001) has found that many of the most innovative scientists have had avocations in the arts and many of the most innovative artists have had avocations in the sciences. Corporate programs, like Xerox-PARC's artist-in-residency program, are predicated on the belief that creativity emerges at the borders between disciplines. Cognitive scientists and creativity scholars argue that the ability to reason by analogy and metaphor are connected to creative

outcomes and that the juxtaposition of different fields of knowledge can expand possibilities for such analogical thinking (Boden 2004).

While the centrality of any institution's broad-based liberal arts training is considered essential to the legitimacy of its entire academic enterprise (Bok 2006; Levine 2006), very little research has been done on the degree to which student course-taking patterns actually reflect this centrality. Certainly, attention has been paid to students' specialization in particular academic fields and the possibility that these specialties *might* threaten student's exposure to a broad range of academic disciplines (Brint, Riddle, Turk-Bicakci, and Levy 2005; Goyette and Mullen 2006; Kirp 2003; Schneider 2005). However, while the alarm has been raised, scant attention has been given to actually determining whether it is true that a broad-based liberal education "has been in retreat . . . giving way to vocational and professional studies, as well as to greater and greater specialization within the arts and sciences" (Kerr 2001:144). Does specialization in the five most common "professional" and "arts and science" majors really decrease academic breadth? If so, is that effect heightened when students add a second major, becoming either more or less specialized in their fields?

This research addresses these questions by examining the relationship between specialization and student exposure to key liberal arts domains of knowledge (e.g., artistic expression, historical consciousness, social analysis, and quantitative literacy). Specifically, we use a concentration measure—the Herfindahl-Hirschman index—to investigate if students' broad exposure to these domains is hampered by their choice of single majors in "practical" or "liberal" arts fields (i.e., specialization), double majors in similar liberal arts fields (i.e., hyper-specialization), or double majors in dissimilar liberal arts fields (i.e, hypo-specialization).

The "Practical Arts," Double Majors and Specialization In Higher Education

In 2002, Steven Brint and colleagues reviewed the forces of change at play in the development of American universities. In that volume, a curricular trend—increases in occupational-professional programs—was highlighted as particularly important in understanding how students would structure the educational credentials they would carry into the 21st century labor market. According to Brint (2002, 2005), nearly 60% of bachelor's degrees are awarded to students majoring in what he calls the "practical arts," a wide-ranging category of majors that includes business, education, engineering, journalism, and nursing. Unlike liberal arts majors, these programs are explicitly vocational, offering specialized technical training meant to prepare students for specific post-baccalaureate occupations. Scholars report that this specialization in applied fields—and a concomitant move away from liberal arts ones—has resulted in sharp declines in student "awareness of different philosophies and cultures [and the] understanding and appreciation of science, literature and the arts" (Brint 2005:152).

In the decade since the publication of Brint's volume, another powerful and completely unexamined curricular trend arose: the propensity for students to graduate with more than one major. According to economists Del Rossi and Hersch (2008), nearly 25% of college graduates have at least two undergraduate majors. At some colleges (e.g., Amherst, Williams, Wellesley), that number can reach as high as 35-40% of any graduating class. While the trend is particularly salient at small, selective private colleges, the pattern is observable at large public institutions as well. For example, the number of students graduating from Florida State University with two majors more than doubled, rising from 426 students in 2001 to 958 in 2009. Nearly 30% of the University of Wisconsin's 2009 graduates had more than one major (Pitt and Tepper 2011).

Given its scope, we know almost nothing about the benefits and drawbacks of the double major. Whether analyzing gender and racial segregation in academic fields (Charles and Bradley 2002; Davies and Guppy 1997; Goyette and Mullen 2006; Jacobs 1995), academic fields' impacts on academic and cognitive development (Arum and Roksa 2011; Charles, Fischer, Mooney, and Massey 2009; Flowers, Osterlind, Pascarella, and Pierson 2001), or the impact of academic field on employment or graduate school (Johnson and Elder 2002; Mullen, Goyette, and Soares 2003; Roksa and Levey 2010; Useem 1989), virtually no research published in the last two decades has accounted for the fact that many

students graduate with at least two majors. It follows then that we also do not know what impact this trend has had on graduates' exposure to a broad range of liberal arts knowledge, exposure deemed critical for students' abilities to interact more effectively in an increasingly interdependent world.

Double majoring is particularly important to our understanding of breadth in students' academic training. Because students can double major in either similar (e.g., biology and chemistry) or dissimilar (e.g., physics and history) fields, the double major combination has the potential to either decrease or increase students' exposure to a broad range of academic subjects. Given that students are taking only about 40 courses over their four-year baccalaureate career, these different kinds of combinations can have a fairly dramatic impact on how many courses they can take. Presumably, students become less (i.e., hypo-) specialized by taking courses in two or more unrelated areas. Splitting their coursework among at least two fields makes it likely that they are not taking as many courses, in either, as their peers who only major in one or the other. They likely have more breadth, but ultimately less depth, than single major specialists. On the other hand, students become more (i.e., hyper-) specialized by doubling-down on courses residing in a particular academic division (e.g., humanities). For example, overlaps in biology and chemistry enable students to understand the physical sciences especially well, but give them little exposure to other fields. This analysis is the first to shed light on the ways hypo-specializing in unrelated majors, and hyper-specializing in related ones, affects the concentration of academic knowledge.

Breadth And Liberal Arts Domains Of Knowledge

Most college catalogs underscore institutional commitments to broad-based liberal education, with faculties attesting to their belief that a broad liberal-arts education is fundamental to the mission of their institutions. Schools champion this perspective in various, but quite similar ways:

> "[Liberal arts exploration] beyond the boundaries of one's intellectual comfort zone in order to admit new ideas is one of the most important aspects of higher education" (Vanderbilt University)
>
> "Liberal education provides students the opportunity for rigorous intellectual encounters with enduring human challenges and important contemporary problems, through wide-ranging exposure to multiple disciplines and ways of knowing." (Virginia Polytechnic Institute and State University)
>
> "[Liberal education] helps students to develop an understanding of the range of processes by which humans generate and affirm knowledge, and to consider several alternative ways of knowing." (Warren Wilson College)

Institutions endeavor to maintain the primacy of these values by requiring all undergraduate students, whether majoring in the "liberal" or the "practical" arts, to take courses that represent breadth in a range of knowledge domains. These requirements—described as the "undergraduate core" or "general education" curricula—are considered a bulwark against student propensities to become too narrowly focused in vocationally-oriented comfort zones. For most schools, the courses that make up these distribution requirements amount to nearly one-third of what students need to graduate (Brint 2009).[2] The most common requirements—often broadly organized in the classic "humanities," "social science," and "physical science" divisions—have been growing steadily in the last three decades (see Table 1).

[TABLE 1 HERE]

Even as these requirements were expanding in both number and prominence in the way students organized their coursework, researchers continued to focus on the demise of liberal education brought on by growth in some academic disciplines (e.g., business, engineering) and declines in others (e.g., history, physics). The narrative of decline is partially a result of an analytical strategy which measures undergraduate exposure to knowledge only in terms of specialized fields of study: academic majors or major concentrations. The unit of analysis is almost always the department or program, with winners and losers being determined by the numbers of students graduating with a particular major listed on their

diplomas. The visibility of majors—via departments, dedicated faculty, and their promotion as "job-specific training"—has enabled the accrual of this "specialized" knowledge to overshadow that of the "general" knowledge that both Becker (1975) and Useem (1989) suggest may be a better long-term investment.

Like another commonly used measure of academic training—years of education—the major a student graduates in has always been a fairly primitive measure of human capital accumulation. First, the specialized credential is no guarantee that students have had the degree of exposure to the specialized knowledge the credential is supposed to signal. What's more, it does not take into account important general knowledge students may have gained in previous majors or the constellation of courses taken as free electives and distribution requirements. Thus, to better understand what students are learning, we must reconsider how we measure exposure to knowledge and, ultimately, what that knowledge might be.

In their synthesis of the empirical evidence of college's impact on students, Pascarella and Terenzini (1991, 2005) show that "what is learned during college is differentially influenced by the pattern of courses taken, even when student ability is controlled" (2005:89). They go on to provide evidence that the number and type of courses taken in liberal arts disciplines—net of the effects of one's major field of study—has a positive impact on the development of verbal, quantitative, and subject matter competence as well as critical thinking and reasoning skills. In light of these findings, more researchers are digging beneath the credential and analyzing course taking patterns with comprehensive analyses of students' undergraduate transcripts (Adelman 2004; Arum and Roksa 2011; Attewell, Lavin, Domina, and Levey 2006; Bound, Lovenheim, and Turner 2010; Charles, Fischer, Mooney, and Massey 2009). Some of these scholars argue that course selection may be the most important decision—more so than even the major—of students' academic careers. Therefore, it is upon student courseloads that we focus our attention.

We argue that most courses taken in both liberal arts and practical arts fields of study can be situated in "domains of knowledge" adopted by most colleges as their general education curriculum. Brint's (2009) survey of general education requirements from 1975-2000 and our own analysis of the 140 colleges/universities in our 2009 sample revealed nine areas that dominate the "traditional liberal arts," "culture and ethics," and "core distribution area" general education models existing on most campuses. While the most common conceptualization of general education requirements takes the form of three core areas—physical sciences, humanities, and social sciences—many institutions are more specific about the domains of knowledge they require as part of these requirements.

Mathematics, which has been historically considered part of the physical science core, now exists as a separate requirement, referred to alternately as either "quantitative" or "formal" reasoning. The broad humanities core—which represents the bulk of what Brint (2009) calls the "traditional liberal arts"—is often broken up into four or five constituent parts: literature, history, religion and philosophy, foreign languages, and the arts. The social analysis core is composed primarily of the social and behavioral sciences. In recent years, a ninth requirement—related to, but listed separately from, the humanities or social science cores—was added to most general education curricula. This category of courses—diversity and global studies—is intended to promote, often in an interdisciplinary fashion, awareness and appreciation of either cultural (e.g., gender, racial, sexual orientation) diversity within the contemporary United States or contemporary global issues. As domains of knowledge, the nine requirements represent training in the modes of inquiry listed in Table 1: artistic expression, literary criticism and composition, foreign languages and culture, historical consciousness, moral and philosophical reasoning, scientific analysis, quantitative literacy, social analysis, and diversity/global studies.[3]

Ironically, framing student learning in these nine seemingly broad domains adds a level of clarity about academic breadth that eludes us if we only focus on the hundreds of narrow fields of study. Majors in all three liberal arts divisions have requirements that draw on a number of these domains, thereby potentially adding breadth as well as depth to the student's training. For example, classics majors take literary criticism, foreign language, moral/philosophical reasoning, and historical consciousness courses (Braswell 2010). Anthropology majors may be required to take courses exposing them to modes of inquiry for historical, social, or scientific analysis; most are also required to take one or more quantitative

literacy (i.e., statistics) courses. While most physical science majors spend much of their time in scientific analysis and quantitative literacy courses, some majors also take social analysis or moral reasoning (e.g., environmental ethics) courses.

With some minor exceptions, courses taken in "practical" arts disciplines also fit within one or more of these nine "liberal arts" domains of knowledge (Braswell 2010). Most engineering courses are, fundamentally, scientific analysis courses. On campuses both with and without business programs, students are gaining "professional" knowledge for business careers in social analysis (e.g., international finance), quantitative literacy (e.g., cost accounting), and even artistic expression (e.g., graphic design) courses. In addition to the subject matter courses required of them, many courses taken by education majors are essentially liberal arts training in social analysis (e.g., educational psychology), literary criticism and composition (e.g., children's literature), and even moral and philosophical reasoning (e.g., philosophy of education).

If we focus on the average set of general education requirements, we find that the base expectation is twelve courses, with one course for each domain of knowledge except scientific inquiry and social analysis which tend to require two courses each. We propose that these requirements—8% for most and 18% for some—stand as a baseline for the amount of breadth institutions desire their students to have. Even with the slightly higher number of courses required in two domains, that slate of twelve courses represents—in percentages—an optimal degree of breadth in liberal arts knowledge. Using a measure of concentration called the Herfindahl-Hirschman index (explained in more detail below), a perfectly balanced slate of courses (i.e., one for each domain) would garner an index score of .10, which is generally the floor for most analyses using the index. The "standard" we propose garners an index score of approximately .11, only slightly higher than a score indicating perfect balance. With that standard in mind, we do three things in our analysis.

First, we measure the degree to which students single-majoring (i.e., specializing) in the five most common practical/liberal arts majors—business, engineering, biology, English, and psychology—take courses approximating this standard for breadth in liberal arts domains of knowledge. We believe that none of these majors actually meets the standard either in terms of breadth (measured as HHI) or actual "market share" of any domain in the constellation of nearly 40 courses most students take. Nevertheless, we will show that some of these majors come much closer than others.

Second, we look more closely at the three liberal arts majors to see if single-majors are significantly different from double-majors in characteristics that may help or hamper student opportunities to take a broader slate of courses. There is some evidence that gender, high numbers of pre-college credits (e.g., Advanced Placement), academic minors, and study abroad experiences may be correlated with both double majoring and course-taking practices (Lewin 2002, Pitt and Tepper 2011).

Finally, we determine if combining liberal arts majors with similar ones—English with other humanities, biology with other physical sciences, and psychology with other social sciences—increases or decreases students' concentration amounts. Similarly, we investigate what impact combining them with different majors might have on the same outcome. We ask if either hyper-specialization or hypo-specialization is different from simply specializing in one field. If there are significant differences, we determine if those differences persist after adding controls and potential covariates into our analysis.

DATA AND METHODS

Sample

Two data sources were used for this project. The primary data comes from a sample of 240 undergraduate student transcripts. The transcripts were used to gather educational histories for each subject. The sample was compiled from subjects who specialize in a single physical science (N=30), humanities (N=30), or social science (N=30) major. We also collected transcripts of double major combinations: two physical sciences (N=16), two social sciences (N=20), two humanities (N=22), physical science and social science (N=16), physical science and humanities (N=17), and social science and humanities (N=19).[4] We also

included engineering (N=20) and business (N=20) transcripts for a total of 240 transcripts. Table 2 describes the sample.

[TABLE 2 HERE]

The transcripts were randomly selected (within the aforementioned categories) from a sample of applications to graduate programs at a large Research I university, but the transcripts represent over 140 colleges and universities. As the applicants were applying to graduate school, many students in the sample have relatively high levels of academic achievement (e.g., high GPA), but these factors were not expected to be relevant for the analysis being performed.

We also included secondary survey data reported in the 2009 Integrated Post-Secondary Educational Survey (IPEDS 2009). IPEDS is a system of interrelated surveys conducted annually by the U.S. Department's National Center for Education Statistics (NCES). The NCES gathers information from every postsecondary educational institution in the United States that participates in federal student financial aid programs. The IPEDS data enables us to control for institutional characteristics that might be correlated with students' course-taking patterns. According to the IPEDS data, our sample and that of the nearly 1500 BA-or-more awarding schools represented in the IPEDS, are similar in terms of student composition, institutional control (e.g., public/private), and Carnegie classifications.

Measures

Dependent Variable

The dependent variables tested in our project are operationalized to measure breadth among college course selection. We coded every course students took by semester and categorized them into the nine domain-of-knowledge (DoK) classifications: artistic expression (ARTS), literary criticism and composition (READ), historical consciousness (HIST), foreign language and culture (LANG), moral and philosophical reasoning (MORL), scientific inquiry (SCIE), quantitative literacy (MATH), social analysis (SOCS), and diversity and global studies (WRLD). While nearly all "professional" courses (e.g., engineering, finance) were appropriate for our domains of knowledge conceptualization, those courses that were explicitly practical in nature (e.g., student teaching) were coded into a miscellaneous (MISC) category. Researchers worked together to code every transcript and any discrepancies were cross-checked using course descriptions from university websites for reliability.

In order to measure breadth among these domains of knowledge, we use the Herfindahl-Hirschman Index as our dependent variable. The Herfindahl-Hirschman Index (HHI), created by economists Orris C. Herfindahl and Albert O. Hirschman, is a measure of the concentration of firms in a given market often used by economics and business scholars (Rhoades 1993, 1995). The HHI is calculated in essentially the same manner as the Simpsons Diversity Index (Simpson 1949) and the Denominational Pluralism Index (Iannaccone 1991) and has been adopted to measure a variety of concepts intended to gauge diversity within a specific area. When used by sociologists, the HHI has been adapted to measure religious competition (Bailey and Taylor 2009, Ellison et al 1997, Rose 2000), racial heterogeneity (Johnson et al 2001, Sampson 1991, Warner and Pierce 1993), and private-public school competition (Belfield and Levin 2002). To our knowledge, this is the first time this index will be used in higher education research.

The HHI is the sum of the squares of the market share of each firm; defined as:

$$HHI = \sum[(x(i)/x)^2]$$

In this equation $x(i)$ is the total number of firm i and x is the total number of all firms in the market; the index is the sum of the squared market shares. To produce an HHI for domains of knowledge, we consider the market shares to be the number of courses taken in each domain divided by the total number of courses completed over the student's academic career. Applying the HHI to knowledge domains, $x(i)$ is the total share of courses within a domain i and x is the total number of courses. Let's take, for example, two students that have completed nine courses. Student A took all nine courses in scientific inquiry, resulting in a 1.0 HHI score. On the other hand, student B took one course in each of the nine domains—giving the student a 0.1 HHI score. In other words, student A was highly concentrated, whereas student B

had total breadth. The higher the HHI, the more concentrated students' course selection is and the less breadth across the domains of knowledge she has. Table 3 shows both the HHI index scores and DoK percentage-shares for the various specializations.[5]

[TABLE 3 HERE]

Independent and Control Variables

Other information from both transcripts and IPEDS was used as independent and control variables in our analysis. The key independent variables are dichotomous variables of each of the nine liberal-arts major types described in the sample: three specialized single-majors, three hyper-specialized double-major combinations, and three hypo-specialized double-major combinations. We also created a "core" variable, "business" variable and "engineering" variable. The first represented the average distribution requirements at each student's school. The second and third accounted for the twenty business single-majors and twenty engineering single-majors, respectively.

Characteristics of the student's collegiate experience, academic achievement, and course selection were used as controls. First, student characteristics were captured by dummy variables indicating whether the subject was female (1=yes), had a minor (1=yes), studied abroad (1=yes), and a continuous measure of institutional costs (i.e., tuition and fees). Academic achievement, operationalized through a continuous four-point grade point average (GPA) and continuous graduate record exam (GRE) scores (verbal, quantitative, and total scores), were also created. Finally, we coded for course characteristics. We included continuous variables for total number of pre-college (e.g., Advanced Placement) courses/credits and also the number of pre-college "courses" specifically in the humanities, physical sciences, and social sciences. A continuous variable for the number of courses students took once matriculated was also used.

While we believe our data collection to be very innovative and valid for answering our research question, it is limited in a few ways. Although there was diversity in both the students and universities represented in our sample, the transcripts we collected did not come from a random, nationally representative sample. We were limited to using only the transcripts available to us—transcripts sent in with applications to graduate programs. There may be some small selection effect in which students who eventually apply to graduate school may select a different set of courses. Another limitation is the lack of demographic information available from the transcript. For example, knowing the subjects' race and socioeconomic class could shed light onto which groups are more likely to specialize in certain ways. On the positive side, both of these limitations creates an open space for other researchers to further test and broaden the findings we report in the pages which follow.

RESULTS

Specialization: Single Majors And Course Concentrations

The first aim of this project is to examine how the liberal arts core is being translated through students' specialization practices. As we explained previously, the average number of courses required in most general education curricula is about twelve, typically one class in every domain of knowledge except for the two in physical science and social science. The nearly even distribution of courses among the domains yields a very low HHI (.107) indicating high breadth among courses.

As Table 3 reveals, specializing—independent of the area(s) or type of specialization—always decreases breadth. However, important patterns are revealed. Probably the most visible finding is the high course count and concentration of science majors. Single science majors have an HHI of .33 and over 54% of their courses fall into the scientific inquiry domain. Relatedly, engineering majors have an even higher concentration (HHI=.50) with over 68% of all courses being in the scientific inquiry domain.

On the other hand, business majors are more similar to humanities and social science specialization patterns. Business majors have an HHI of .26, humanities majors have an HHI of .26, and social science majors have the lowest measure of concentration among single majors with an HHI of .25. Looking at the liberal arts domains' percentages, we can see that, unlike the engineering and physical science majors,

none of the domain percentages dips below two percent for business, humanities, and social science majors. For instance, eight of the ten domains for social science majors have course percentages between 4% and 10%. Compared to the other majors, this distribution is the most evenly dispersed; single majors in the social sciences have the most breadth.

Differences Between Liberal Arts Single Majors and Liberal Arts Double Majors

Examining only single majors limits our understanding of breadth and course selection to single area specialization only. As we've detailed, many students are graduating with multiple majors and therefore either becoming more specialized or less so. Understanding these dynamics is an important part of fully understanding the contemporary student experience. Therefore, the final two questions addressed in this paper focus on differences between single and double majors. First, we will describe characteristic differences and then return to our discussion of breadth.

Descriptive statistics for variables in our analysis are presented in Table 2. In order to analyze whether there are differences between students who have a single major and those who double major, we conducted t-tests. This calculation tests whether the means of two normally distributed populations are equal. Table 2 reveals interesting distinctions.

Of the student characteristics, results show that there are some significant differences between single majoring specialists and double majoring hypo- and hyper- specialists. As one would expect, double majors are less likely than single majors to have minors. This is the case broadly and for hyper-specialists. Surprisingly, hypo-specialists are not significantly different from single majors in this regard. In spite of having two dissimilar majors, these students are more likely than students with similar majors to add yet another field of study to their training. We suspect that hypo-specialists are purposeful in their attempt to take full advantage of a diverse liberal arts education. Study abroad percentages support this conclusion. More hypo-specialists (almost 33%) study abroad than either specialists (23%) or hyper-specialist (26%), giving them even more exposure to a range of academic experiences. While the average tuition cost for hyper-specializing double majors is higher than that of single majors, this difference isn't statistically significant. As mentioned earlier, the levels of academic achievement are relatively high for the total sample; the average GPA is 3.57 and total GRE score is 1279. There are no significant differences between single majors and double majors.

Perhaps the most revealing distinctions come from course characteristics. Double majors come to college with a significantly higher number of advanced-placement[6] course-credits. On average, double majors have four or more course-credits completed before entering college, whereas single majors have, on average, slightly less than three. Furthermore, hypo-specialized majors have significantly more science and humanities course-credits than single majors. Not surprisingly, double majors also take more actual courses once matriculated. From these results, we suspect that having even one or two more course-credits completed prior to entering college open up opportunities to complete more courses, study abroad, and even double major. Conversely, students without this kind of academic headstart may not have the ability to schedule the extra courses required to double major and may choose to minor instead.

Hyper-Specialization and Hypo-Specialization: Double Majoring And Course Concentrations

With that foundation, we now turn to look at the degree to which different levels of specialization might affect students' broad exposure to the domains of knowledge. Single majoring represents a kind of middle-ground where the bulk of students' courses give them a specialty in one field of study (e.g., psychology). Hypo-specializing double majors are less specialized because they, undoubtedly, have fewer courses in any one field of study or courses that deepen their understanding of that field because of divisional (e.g., social science) similarities. Hyper-specializing double majors are the most specialized because the two fields are related (at least in terms of divisional cluster) and courses are, presumably, overlapping in terms of the knowledge they cover.

The HHI averages for both single majors and the various double major combinations are shown in Table 2. Remember, the lowest HHI a student can attain is .10 because of the general education

requirements on most campuses. The average HHI is .29 for the total sample. Broadly, single majors are neither more nor less concentrated than double majors. It is only when we look at the double major specializations that differences in concentration are revealed. Double majors who hyper-specialize are the most concentrated with an HHI of .33. Conversely, double majors who hypo-specialize have a low HHI of .26. Specialists (HHI=.28) lie between these poles. Clearly, taking required and elective courses for two majors in non-overlapping fields creates more diversity among courses. On the other hand, taking required and elective courses for two majors in similar fields creates more concentration among courses.

Returning to Table 3, we can see how course concentrations differ by hyper- and hypo-specialization in specific liberal arts fields. Generally, humanity majors have the lowest concentration of domains. Moreover, there are no significant differences in breadth among humanity majors that specialized (HHI=.26), hyper-specialize (HHI=.24) or hypo-specialize (HHI=.25). In contrast, like engineering, majoring in a physical science is associated with high concentration. The HHI for science specialists is .35; science hyper-specialists (HH1=.41) are even more concentrated. It should be noted that when science majors choose dissimilar second majors, they become significantly less concentrated (HHI=.27) than their single major counterparts. However, looking at the specific hypo-specializing combinations,we can see that students double-majoring in at least one science have less breadth than those without a science major at all. Examining the course selection among social science majors reveals a complex pattern. Again, social science specialists have the highest breadth (HHI=.25) among all other single majors. Social science hypo-specialists have similarly low levels of concentration (HHI=.26); they're not significantly different from specialists. However, hyper-specialists in the social sciences are highly concentrated (HH1=.38) and significantly different from their single-majoring peers.

[TABLE 4 HERE]

Considering the various distinctions between single and double majors, in general and within core distinctions, we decided to examine multivariate correlations. In the final portion of our analysis, we used ordinary least squares regression to predict HHI by major type. Ordinal least squares regression was chosen because it is the best linear unbiased estimator for cumulative scaled variables[7]. Informed by our exploratory bivariate analyses shown in Table 2 and correlational analyses between the dependent and independent variables (not shown), we regressed the Herfindahl-Hirschman Index on specialization type, controlling for total courses, total pre-college credits, gender, minor, study abroad experience, and tuition.

Examining the R^2 reveals that the hyper/hypo-specialization distinction increases the explanatory power of the models; grouping all double majors together limits the conclusions one can make. The positive association between hyper-specialization and concentration and the negative association between hypo-specialization and concentration is one reason for the greater explanatory power. Once any effects of student characteristics and number of pre-college and college courses are parceled out, the regression analysis confirms what we described earlier. Column A (Table 4) shows that hyper-specialists are more concentrated than specialists by .03 units and hypo-specialists are less concentrated by .04 units.

Column B presents results of the humanities sample. Holding the controls constant, no significant differences between the degree of specialization are revealed. In column C, however, we see that hyper-specialists in the social sciences have a significantly higher concentration, by .10 units, than specialists. Finally, column D presents results from the physical science sample. Again, double majors, independent of the degree of specialization, are not significantly different from single majors. However, there is a positive association between hyper-specialization and concentration; hyper-specialists are .06 units more concentrated. Hypo-specialists, on the other hand, are significantly less concentrated than specialists by .09 units.

These regressions confirm the bivariate findings that degree of specialization impacts concentration in different ways. Humanities majors do not differ from each other in terms of concentration, regardless of specialization. However, students who hyper-specialize in the social sciences and physical sciences become significantly more concentrated than specialists, while students who hypo-specialize in the physical sciences become significantly less concentrated than their counterparts.

DISCUSSION AND CONCLUSIONS

In this article, we examine the relationship between academic specialization and student exposure to a range of academic domains of knowledge. Our findings reveal notable differences in the ways practical arts and liberal arts specializations impact students' broad exposure to a variety of academic insights and modes of inquiry. When breadth is measured by exposure to multiple domains of knowledge and not simply courses taken in different departments, it is clear that the concerns raised about the "practical arts" are warranted in some cases, but not in all of them. Business specialists (HHI=.26), with their courses in business communications, economic theory, and accounting principles, have as much breadth in the nine liberal arts domains as any social science (HHI=.25) or humanities (HHI=.26) specialist. Of the courses business majors might take in their academic career, similar numbers of courses are taken in the three broad areas of liberal-arts inquiry: twelve in the humanities, nine in the physical sciences, and sixteen in the social sciences. We argue that other professional specialties, like communications and education, would be similar in terms of breadth.

In sharp contrast to business majors, the average engineering major is exposed to virtually no liberal-arts knowledge beyond that taught in physical science courses. If one considers that most of their humanities classes are actually "technical writing" or "technical design" courses, it is likely that they are learning to communicate effectively, but are not exposed to much in terms of broad artistic or literary aesthetics. Other science-oriented professional specialties, like nursing and agricultural production, would likely suffer from the same impediment. While this kind of academic concentration is problematic, most colleges and universities do not have these kinds of programs. The trend towards academic concentration we expose in engineering is seen more pervasively in the "science" side of the liberal arts and science continuum.

Students majoring in biology, likely the least specialized of the most common science majors, have less breadth than students majoring in English or psychology; nearly two-thirds of their courses are scientific or quantitative analysis classes. When these students hyper-specialize in the sciences, adding a second major in another science, their exposure to courses which expand their awareness of economic, political or social issues (the "social analysis" domain) is nearly halved. If it is in these courses that students gain the tools to become informed participants in business, civic, or community life, many of these students are going to find themselves at a considerable disadvantage. If the "problem" of vocationalism is *concentrated knowledge*, the lack of breadth we see in the "liberal arts" sciences suggests that those fields—biology, chemistry, physics, mathematics—are as vocational as some of the "practical arts" ones.

The significant reduction in academic breadth caused by hyper-specialization in the physical sciences can also be observed in the social sciences. Specifically, when psychology majors add another social science major (e.g., sociology), they have less breadth than psychology single majors and are as concentrated as biology single majors, just in different ways. The increase in social analysis courses (about 5) is balanced by equal losses (about 1 course each) in both humanities and physical science oriented domains of knowledge. While hyper-specialization in the social sciences can be as problematic as it is in the physical sciences, social science majors—particularly sociology, economics, and anthropology—are uniquely situated in terms of breadth. Social science single-majors take as equal a share of courses across the nine domains as either humanities single- *or* double- majors, in spite of the fact that five or six of the domains fall into the humanities core. As suggested earlier, this is a function of the competencies in history, foreign languages, composition, and quantitative literacy required by many social science fields. A successful sociology major, particularly one planning to pursue a graduate degree, would need to have both exposure to and some mastery of all of these very different domains of knowledge. This unique characteristic of social science majors makes it a particularly potent (in terms of adding breadth) addition to either a humanities or physical science major. In both cases, the student's courseload becomes less concentrated when combined with a social science major; this is especially true for the physical sciences.

While hyper-specialization has a negative impact on social science and physical science major's exposure to a broad range of academic knowledge, a student's hyper-specialization in humanities fields seems to have no effect on this institutional goal. In fact, neither the addition of a related major (e.g., history) nor a dissimilar one (e.g, physics) has any significant impact on the breadth of exposure represented in English majors' course-loads. A close examination of humanities hyper- and hypo-specialization uncovers two different dynamics at work that explain this stability. As we mentioned above, the humanities core represents five domains of knowledge. If an English major adds History as a second major, two things happen. First, the number of courses he takes increases to account for this addition. This suggests that slightly less overlap exists between humanities courses than there might be in social science or physical science courses, where we don't see an attendant increase in courses with hyper-specialization. The remaining changes are minor ones, with swaps among humanities domains that don't have any real effect on the overall balance among the five of them. In the English-History example, they simply take slightly fewer literary criticism/composition courses and slightly more historical consciousness courses than they were taking as English single-majors.

When the English major adds physics as a second major, there is also an increase in the number of courses. As we suggested previously, these increases may be a signal that there is little overlap between the two majors, so students have to take more courses to fulfill each majors' requirements. Also, as we saw with humanities hyper-specialists, hypo-specialists maintain breadth by shifting shares from one domain to another. In this case, the shifts are more dramatic, with the swaps occurring between the most influential humanities domain and the domain covered most intensely by the second major's courses. If that major was physics, the fifteen literary criticism/composition classes typically needed to complete the English major would be replaced with fifteen scientific inquiry courses. The ensuant decrease in literary criticism/composition exposure would be lessened by a decrease in exposure to some other humanities domain. That decrease is most strongly felt in the historical consciousness domain. Therefore hyper-specializing humanities double majors maintain balance by reducing breadth among the humanities domains in order to increase their exposure to the dissimilar ones. This trend has a very important implication: when students double major in a humanities field and either a social science or physical science field, the *primary* field is the social or physical science one.

Of the three core divisions in the arts & sciences, the humanities suffers most when students either hyper- or hypo-specialize. It is important to recognize that while the most important rationale for breadth is the benefits students receive, students' broad-ranging exposure to various domains of knowledge has implications for another potential beneficiary: the departments who offer training in this knowledge. This has always been a benefit of general education requirements, which offer stability for many departments, particularly those in the humanities (Brint et al 2005). If students weren't required to take one or two courses in each domain, many would graduate with virtually no exposure (0-1 courses) to some knowledge and the departments where it is taught. As specialization reduces student opportunities to take courses in domains unrelated to those specialties, departments most responsible for those domains lose market share. Single majors and hyper-specializing double majors are especially susceptible to this possibility. Our findings show that the biggest losers in this case would be departments that teach artistic expression, historical consciousness, foreign language and culture, moral and philosophical reasoning, and diversity studies. This problem is heightened by student demands to receive AP examination credit in literature, composition, history, and foreign language, thereby avoiding college exposure to these domains altogether. Therefore, if institutions are serious about giving students more than a cursory encounter with the humanities, it behooves them to be thoughtful about the ways students are combining specialties that reduce student exposure to the full range of humanities knowledge.

Taken together, these findings suggest that the study of higher education can benefit from further analysis of the impact of both hyper- and hypo-specialization on higher education outcomes. One of our objectives is to provide a rationale for further study of this trend and to illustrate how an appreciation of this growing phenomena can translate into empirical inquiry about its impact. The rise of double majors is perhaps the most significant trend in the curricular lives of today's students. Understanding this

phenomena is critical to a comprehensive understanding of the impact of postsecondary institutions on their matriculants.

Research suggests that nearly a third of double majors are choosing fields located in similar core areas; they are hyper-specializing (Pitt and Tepper 2011). If hyper-specialization is negatively correlated with one major aim of higher education institutions—breadth of knowledge—what impact might it be having on others? Are hyper-specialists at a disadvantage in terms of being able to think analytically, to develop intellectual curiosity, or gain the intellectual habits that will enable them to become lifelong learners? Conversely, are they benefitting by gaining a deeper understanding in two areas that complement and reinforce one another in terms of skills and knowledge?

The remaining two-thirds of double majors, the hypo-specialists, have as much or more breadth as students specializing in one liberal arts or professional field. While broad exposure is valuable on its own, are students finding opportunities to integrate the knowledge they've been exposed to? Does this broad exposure give students either short-term or long-term advantage in the labor market? Are there other ways that double majoring in dissimilar fields may be benefitting these students?

Even more importantly, who are these students? The extant research on the impact of single majors suggests that student enrollment in majors is stratified by race, gender, and class. Might double-majoring, and particularly the tendency to hypo-specialize when doing so, be associated with these same demographic characteristics? For example, majoring in the "practical arts" is significantly correlated with socioeconomic status; lower-SES students are more likely to pursue these degrees. If socieoeconomic status is correlated with either propensity or, more likely, ability to double major, are the positive outcomes that may accrue from double majoring unequally distributed among the college-educated population? While scholars often speak of choices that students make, it is likely that there is more to any graduate's story than choice. Rather, decisions students make about coursework and field of study are likely tied to the opportunities available to them. Further examinations of *the who*, as well as *the what*, of academic specialization, especially through the selection of multiple majors, can strengthen our understanding of the extent of the benefits of postsecondary education.

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Notes

1. Only 35% believe its main purpose is to teach skills and knowledge that can be used in the workplace.
2. Some notable liberal arts colleges—Brown University, Amherst College, Smith College—do not have distribution requirements.
3. In addition to these nine domains, many schools require courses designed to acclimate students to the institutions (e.g., freshman seminars) or train them in practical life-style skills (e.g., physical education, personal health, leadership). These and other explicitly practice-oriented courses (e.g., student teaching, internships) are accounted for in our analyses in a "miscellaneous" category.
4. Specifically, we selected transcripts from students with at least one of the following majors: Biology (physical sciences), English (humanities), and Psychology (social sciences). The selected fields are majors that have the highest undergraduate enrollment rates nationally. In an additional analysis not reported here, we added other majors to ensure that our results could be generalized beyond these three. There were no significant differences between the models, so for clarity we limited the reported analysis to these 200 cases.
5. The data in this table's first row, "Liberal Arts Core," was derived by coding the general education requirements for each school represented in our student sample and then determining average requirements for all 240 students.
6. This includes course-credit gained through International Baccalaureate coursework, community college courses taken before the student matriculated, and (most commonly) Advanced Placement examination.
7. All assumptions for this model are met satisfactorily. Tests for influential data were completed and although a few outliers were detected, they were not influential. Most of the outlier data points were from subjects who hyper-specialize in physical sciences; therefore, it is not surprising that they have the highest HHI numbers.

Table 1: Percentages of Key General Education Requirements In College/University Catalogs

General Education Requirements	Brint (1975)[1] N=292	Brint (2000)[1] N=292	Authors (2009)[2] N=145
Literature & Arts, Humanities	36.6	36.6	59.5
Artistic Expression (ARTS)	19.9	37.7	59.5
Literary Criticism and Composition (READ)	20.2	34.9	81.0
Foreign Languages and Culture (LANG)	20.6	22.3	66.7
Historical Consciousness (HIST)	10.3	22.6	54.8
Moral and Philosophical Reasoning (MORL)	16.8	15.4	40.5
Scientific Analysis, Natural Sciences (SCIE)	45.6	52.4	100.0
Quantitative Literacy (MATH)	18.8	47.6	92.9
Social Analysis, Social Sciences (SOCS)	63.4	65.8	95.2
Diversity/Global Studies (MIXD)	2.1	17.8	56.8

[1] Brint et al (2009)
[2] Authors' (2010) sample

Table 2. Descriptive Characteristcs For Study Variables (Liberal Arts Majors Only)

	A. Total Sample		B. Single Majors		C. Double Majors		D. Hyper-Specialized Double Major		E. Hypo-Specialized Double Major	
	Mean/ Percent	SD	Mean/ Percent	SD	Mean/ Percent	SD	Mean/ Percent	SD	Mean/ Percent	SD
Student Characteristics										
Female (1=Yes)	63.50	.48	54.44	.50	70.91*	.46	67.24	.47	75.00*	.44
Minor (1=Yes)	22.00	.42	30.00	.46	15.45*	.36	12.07*	.33	19.23	.40
Study Abroad (1=Yes)	24.50	.44	18.89	.39	29.09	.46	25.86	.44	32.69	.47
Institution Tuition	22403	14159	22192	14459	20752	13938	18730	13513	22967	14189
Student Achievement										
Grade Point Average	3.57	.32	3.55	.34	3.60	.30	3.6	.31	3.56	.30
Composite GRE Score	1279.65	121.23	1278.44	116.68	1280.64	125.37	1261.90	108.86	1261.90	139.66
Verbal	592.30	90.97	588.33	92.59	595.55	89.92	588.10	96.13	603.85	92.76
Quantitative	687.35	72.78	690.11	76.50	685.09	69.86	673.79	66.65	697.69	71.83
Course Characteristics										
Total Courses	37.61	6.64	36.38	6.78	38.61*	6.34	38.35^{+}	7.08	38.90*	5.57
Total Pre-College Courses	3.89	3.30	2.96	2.75	4.66***	3.52	4.21*	3.00	5.15***	3.98
Humanities	1.78	1.90	1.22	1.61	2.23***	2.00	2.16**	1.97	2.31***	2.05
Social Science	.48	.87	.50	1.02	.46	.74	.45	.71	.46	.78
Physical Science	1.45	1.97	.99	1.50	1.82**	2.23	1.36	1.79	2.33***	2.55
Herfindahl-Hirschman Index	.29	.09	.28	.08	.30	.10	.33**	.10	.26	.08
Number of Cases	200		90		110		58		52	

+p<.10 *p<.05 **p<.01 ***p<.001 **Note:** Means are compared to single majors.

Table 3. Liberal Arts Domains Of Knowledge, Course Counts, and Herfindahl-Hirschman Indexes For Key Student Curricula

	Course Count	HHI	LIBERAL ARTS DOMAINS OF KNOWLEDGE (PERCENTAGE-SHARES)									
			ARTS	READ	HIST	LANG	MORL	SCIE	MATH	SOCS	WRLD	MISC
Liberal Arts Core	12.34	0.107	7.9	11.6	9.7	10.5	7.4	14.6	10.3	12.9	5.3	9.8
Business	38.75	0.264	3.9	5.2	5.9	10.2	4.7	4.6	18.0	39.5	0.5	7.5
Engineering	40.50	0.504	0.8	4.4	2.1	0.3	3.0	68.4	12.3	4.3	0.2	4.2
Humanities Majors												
Specialization	33.53	0.258	2.5	40.4	11.0	8.0	5.1	10.9	3.8	8.4	5.7	4.3
Hyper-specialization	37.77	0.240	3.5	37.2	8.9	9.8	12.3	5.3	3.0	5.3	6.8	8.0
Hypo-specialization	39.61	0.254	6.5	19.0	3.4	9.4	6.0	20.1	5.8	21.5	3.5	4.7
Social Science Majors												
Specialization	35.07	0.247	4.0	6.8	6.0	8.0	5.9	10.4	8.3	40.0	4.7	5.8
Hyper-specialization	35.70	0.375***	1.3	4.5	5.5	5.4	5.0	7.5	5.6	57.4	3.0	4.9
Hypo-specialization	37.80	0.260	4.0	13.4	3.9	7.1	4.2	19.8	7.1	31.8	3.3	5.4
Physical Science Majors												
Specialization	41.16	0.348	2.4	5.8	5.4	4.4	3.2	54.3	9.4	6.6	3.3	5.1
Hyper-specialization	42.50	0.408*	4.1	4.1	4.8	2.1	4.6	60.9	8.6	4.1	1.5	5.2
Hypo-specialization	39.30	0.273***	5.7	10.3	4.0	6.5	5.2	34.7	9.7	16.3	2.0	5.7
Cross-Majors												
Humanity & Social Science	38.21	0.243	5.0	21.4	3.4	9.8	5.0	7.1	3.5	35.6	4.7	4.5
Social Science & Science	37.31	0.280	2.9	3.8	4.6	3.8	3.2	34.9	11.3	27.3	1.7	6.4
Science & Humanity	41.18	0.267	8.3	16.3	3.4	9.0	7.2	34.6	8.3	5.8	2.2	4.9

+p<.10 *p<.05 **p<.01 ***p<.001 **Note:** Means are compared to single majors.

Key: Herfindahl-Hirschman Index (HHI) • Artistic Expression (ARTS) • Literary Criticism and Composition (READ) • Historical Consciousness (HIST) • Foreign Language and Culture (LANG) • Moral and Philosophical Reasoning (MORL) • Scientific Inquiry (SCIE) • Quantitative Literacy (MATH) • Social Analysis (SOCS) • Diversity/Global Studies (WRLD) • Miscellany (MISC)

Table 4: OLS Regression Predicting The Herfindahl-Hirschman Index[a] (Single Majors Are The Comparison Group)

	A. Total Sample		***B. Humanities***		***C. Social Sciences***		***D. Physical Sciences***	
All Double Majors	0.007		0.003		0.036		-.0.034	
	(0.01)		(0.02)		(0.03)		(0.02)	
Hyper-Specialized Double Majors		0.038*		-0.008		0.100****		0.058*
		(0.02)		(0.02)		(0.02)		(0.02)
Hypo-Specialized Double Majors		-.032**		0.012		-0.015		-0.091***
		(0.02)		(0.02)		(0.02)		(0.02)
Constant	0.289***	0.269***	0.336***	0.345***	0.473***	0.394***	0.323***	0.348***
Adjusted R^2	0.059	0.140	0.143	0.161	0.300	0.522	0.043	0.356
N	***200***		***88***		***85***		***79***	

+p<.10 *p<.05 **p<.01 ***p<.001 **Note:** Standard errors are in parentheses

[a] Model controls for minor (1-yes), study abroad (1-yes), female (1-yes), total courses, total pre-college courses, and university tuition