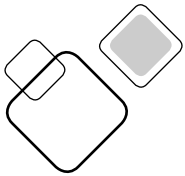

Academic Specialization, Double Majoring, and the Threat to Breadth in Academic Knowledge

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ABSTRACT | This article examines the relationship between academic specialization and student exposure to a range of academic domains of knowledge. It uses a concentration measure–the Herfindahl-Hirschman Index–to investigate whether students who choose single majors or double major are more or less concentrated in nine domains of knowledge most postsecondary institutions consider to be the intellectual core of a liberal arts general education. The results, based on an analysis of 240 undergraduate transcripts, indicate that–relative to single majoring–choosing similar majors (hyperspecialization) significantly concentrates student learning and choosing very different majors (hypospecialization) leads to more breadth.

KEYWORDS | higher education, liberal arts education, academic specialization, college majors, double majors

A Pew Research Center (Taylor et al., 2011) study shows that 52 percent of college graduates believe the main purpose of college is to help individuals grow personally and intellectually,[1] while students elsewhere also shared beliefs that a general education is supposed to produce "well-rounded and responsible citizens" (Thompson, Eodice, & Tran, 2015, p. 289). In a survey of nearly five hundred 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; they are

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also commonly perceived goals of baccalaureate-level training more generally. The latter of these aims—breadth—sits at the heart of the creation of the type of Renaissance student many associate with a baccalaureate degree and the intellectual growth it fosters.

Many colleges and universities recognize the inherent value of broad-based liberal arts training, even considering it essential to the legitimacy of their entire academic enterprise (Bok, 2006; Levine, 2006). For example, the University of California, Merced (UCM), describes "depth and breadth in academic and intellectual preparation" as a hallmark of its baccalaureate education and identifies having UCM graduates "engage in interdisciplinary thinking which could include appreciating different approaches to problem solving, informed by an understanding of the humanities, arts, STEM, social sciences" as the preeminent goal for the twenty-first-century research university. Like many schools, UCM has put these values into practice by creating a general education curriculum that serves as a cornerstone of its educational mission.

According to Hurtado, Astin, and Dey (1991), two prominent features of general education include flexibility in course-taking practices and interdisciplinarity of coursework. Yet, while a general education is important to the mission of many colleges and universities, very little research has been done on the degree to which student course-taking and majoring patterns might inhibit schools' aims to expose students to multiple disciplines. Some scholars have examined students' specialization in applied and professional fields (e.g., business, engineering) and the possibility that these specialties *might* threaten students' exposure to a broad range of academic disciplines, but none actually determine whether this is true (Brint, Riddle, Turk-Bicakci, & Levy, 2005; Goyette & Mullen, 2006; Kirp, 2003; Schneider, 2005). Others have written about this retreat away from general/liberal education as a consequence of the rise of the neoliberalism infiltrating norms in higher education through the emphasis on knowledge as economic capital rather than human capital (Olssen & Peters, 2005; Shore, 2010). Kerr asserts 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" (2001, p. 144). Similarly, Aloi, Gardner, and Lusher (2003) argue that the call for accountability in higher education should not only focus on academic achievement and graduation rates but additionally assess the extent to which broad knowledge and skills are being imparted through a general education.

While we do not discount these findings, we believe that they only tell part of the liberal arts story. We argue that scholars have too often conflated graduating with a "liberal arts major" with graduating with a more general "liberal arts education." A specific liberal arts major serves as a *signal* or credential to

future employers that a graduate has (or does not have) a specialized set of skills. A liberal arts education, on the other hand, should represent the broad set of academic competencies students accumulate as a function of exposure to a number of academic disciplines within a general education curriculum. While the alarm has been raised, scant attention has been given to actually determining whether it is true that academic specialization—whether in professional studies or liberal arts majors—reduces student exposure to a broad range of knowledge. Meanwhile, a new form of specialization has arisen among the curricular options that may further reduce, or possibly increase, this kind of exposure. That form of specialization is double majoring.

This growing trend—graduating with more than one major—may be a mechanism for more varied exposure to the general education curriculum, but it may also lead to a narrowing of students' experiences. According to Del Rossi and Hersch (2008), nearly 25 percent of college graduates have at least two undergraduate majors. At many elite colleges (e.g., Amherst, Wellesley), that number can reach as high as 35–40 percent of any graduating class. A recent study sought to explore the impetus for and impact of double majoring and found that some students *are* electing to double major to better achieve a true general education (Pitt & Tepper, 2013). The researchers quote Caroline, one of these students, who revealed that she felt her double major in math and French allowed her to engage with "both sides, like the science side and the humanities side. For me, that's what I was looking for: one major that would be the more 'sciency,' logical side of me; and one that would be more like the conceptual, philosophical side" (Pitt & Tepper, 2013, p. 30). The question remains though: Is Caroline right? Does a double major on seemingly different sides of the liberal arts spectrum, what we call "hypospecialization," increase exposure to multiple disciplines and ways of knowing? What about Caroline's peers who believe that the same thing happens when they hyperspecialize by selecting two majors on similar sides of the spectrum, such as math and biology or French and English? Having two majors may appear to signal the accumulation of more knowledge, but does double majoring really mean that students have gained a broader (or for that matter, deeper) level of exposure to academic knowledge? This analysis is the first to provide empirical answers to what is, at this point, only conjecture.

We ask the following questions: Does specialization in one of the five most common professional and arts and science cognate clusters—business, engineering, the humanities, social sciences, and natural sciences—decrease academic breadth? If so, is that effect heightened when students add a second major, becoming either more or less specialized in these academic divisions? Before doing so, we review the role breadth of knowledge plays as a central benefit of a liberal education curriculum and the role the potential professional

majors, double majors, and even single liberal arts majors themselves may play in counteracting that benefit. We then describe the domains of knowledge that sit at the heart of the general/liberal education ethos and, therefore, are the focus of our investigation.

Breadth in Higher Education

Most college catalogs underscore institutional commitments to broad-based general 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 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 Tech)
>
> [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)

According to Goyette and Mullen (2006), "Liberal learning values breadth of knowledge over narrow specialization and holds an appreciation of learning for its own sake rather than utilitarian ends" (p. 498).

That said, a general education—particularly one characterized by exposure to 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 webs of interdependencies. In short, Renaissance people . . . are 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" (p. 368). In effect, Kanter suggests that the most innovative workers are those whose exposure to a broad range of fields has given them the tools necessary to be especially productive in society. Academic breadth, then, would be precisely the type of investment human capital theorists such as Becker (1964) and Schultz (1961) might recommend.

The root of innovation—creativity—has long been associated with knowledge that spans different subject areas and fields of inquiry. Root-Bernstein (2001; Root-Bernstein, Bernstein, & Garnier, 1995) 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, such as 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 is connected to creative outcomes and that the juxtaposition of different fields of knowledge can expand possibilities for such analogical thinking (Boden, 2004).

Despite the significance that institutions place on general education, there is increasing reason to believe that it is not being achieved in the trend toward a neoliberal approach to educating students in today's universities. In a review of the forces of change at play in the development of American universities, Brint and colleagues find that curriculums now emphasize occupational-professional programs (Brint, 2002; Brint et al., 2005). Nearly 60 percent of bachelor's degrees are awarded to students majoring in 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 postbaccalaureate 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 et al., 2005, p. 152).

Even academic advisers report being tasked to help students "balance the breadth provided by general education with the depth and specialization of the major" (Guertin, 2015, p. 138). However, the visibility and promotion of these majors have enabled the accrual of this so-called specialized knowledge to overshadow the value of the "general" knowledge that both Becker (1964) and Useem (1989) suggest may be a better long-term investment. Thus, it appears that there may be diminishing returns to academic specialization, at least in terms of exposure to a broad range of intellectual traditions, modes of inquiry, and academic domains of knowledge. We pursue answers to this question in this article, but we add an important correction to the conventional characterization of all professional fields as too specialized and all liberal arts fields as comprehensive in terms of breadth. By setting professional fields against "liberal arts" fields, researchers overlook the possibility that even students' majors in those nonprofessional disciplines may reduce students' exposure to a broad

range of academic knowledge. What is more, this concentration may be exacerbated by a phenomenon many have overlooked: the propensity for students to graduate with more than one liberal arts major.

Double Majoring and Academic Breadth

In the decade after the publication of Brint's volume, another powerful and virtually unexamined curricular trend arose: the propensity for students to graduate with more than one major. As we describe in the introduction, nearly 25 percent of students double major, a number that can grow to 40 percent on some campuses. While the trend is particularly salient at 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 percent of the University of Wisconsin's 2009 graduates had more than one major (Pitt & Tepper, 2013).

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 & Bradley, 2002; Davies & Guppy, 1997; Goyette & Mullen, 2006), academic fields' impacts on academic and cognitive development (Arum & Roksa, 2011; Charles, Fischer, Mooney, & Massey, 2009), or the impact of academic field on employment or graduate school (Johnson & Elder, 2002; Roksa & Levey, 2010), 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.

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 and thus has the potential to either enhance or hinder students' human capital accumulation. Presumably, students become less (i.e., hypo-) specialized by taking courses in two or more unrelated areas. Splitting their coursework among two very different fields makes it likely that they are not taking as many courses in either major 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 within a particular academic division (e.g., the humanities only). 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 hypospecializing in unrelated majors and

hyperspecializing in related ones may affect the concentration of academic knowledge.

Domains of Knowledge as an Analytical Tool

Institutions endeavor to maintain the primacy of breadth as an intellectual value 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 "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, Proctor, Murphy, Turk-Bicakci, & Hanneman, 2009).[2] The most common requirements—often broadly organized in the class "humanities," "social science," and "physical science" divisions—have been growing steadily in the last three decades (see Table 1).

Table 1 | Percentages of Key General Education Requirements in College/University Catalogs.

General Education Requirement	*(1975), N = 292*	*(2000), N = 292*	*(2015), N = 145*[a]
Literature and 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 inquiry, 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 (WRLD)	2.1	17.8	56.8

[a] Based on the coding of our random sample of baccalaureate, master's-granting, and doctoral-granting institutions' course catalogs with any general education requirements. 1975 and 2000 requirements are from Brint et al. 2009; 2015 requirements were used in this study.

In their synthesis of the empirical evidence of college's impact on students, Pascarella and Terenzini (2005) show that "what is learned during college is differentially influenced by the pattern of courses taken, even when student ability is controlled" (p. 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—have 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 credentials and analyzing course-taking patterns with comprehensive analyses of students' undergraduate transcripts (Adelman, 2004; Arum & Roksa, 2011; Attewell, Lavin, Domina, & Levey, 2006; Bound, Lovenheim, & Turner, 2010; Charles et al., 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 course loads 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 et al.'s (2009) survey of general education requirements from 1975 to 2000 and our own sample of student transcripts from 140 colleges/universities (see the "Data and Methods" section for more information) reveal nine areas that dominate the general education models existing on many campuses. While the most common conceptualization takes the form of three broad cognate areas—humanities, natural sciences, and social sciences—many institutions are more specific about the domains of knowledge they require as part of these requirements.

The broad humanities core represents the bulk of "traditional liberal arts," according to Brint et al. (2009), and is often broken up into four or five constituent parts: literature, history, religion and philosophy, foreign languages, and the arts. The natural sciences core, which focuses on scientific analysis of the natural world, usually requires students to take courses in both physical (e.g., physics, chemistry) and life (e.g., biology) sciences, often with attendant laboratory sections. Mathematics, which was historically considered part of the natural sciences core, now exists as a separate requirement, referred to alternately as either "quantitative" or "formal" reasoning. The social analysis core is composed primarily of the social and behavioral sciences. In recent years, a ninth requirement—diversity/global studies—was added to most general education curricula; 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 inquiry, quantitative literacy, social analysis, and diversity/global studies.[3]

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 inquiry courses. On campuses both with and without business programs, students gain "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 (i.e., "core") requirements on the 140+ campuses represented in our study, we find that the base expectation—separate from any requirements for particular majors—is twelve courses,[4] 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 percent for most and 18 percent 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 0.10, which is generally the floor for most analyses using the index. The "standard" we propose garners an index score of approximately 0.11, 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, because of students' preferences and disciplinary constraints. Nevertheless, we will show that some of these majors come much closer to the standard than others.

Second, we look more closely at the three liberal arts majors to determine whether combining liberal arts majors with similar ones—English with other

humanities, biology with other natural sciences, and psychology with other social sciences—increases or decreases students' concentration, particularly and broadly. Similarly, we investigate what impact combining them with different majors might have on the same outcome. We ask whether either hyperspecialization or hypospecialization is different from simply specializing in one field.

Finally, if there are significant differences, we determine whether those differences persist after adding controls and potential covariates into our analysis. Using an ordinary least squares regression, we expect to find that hyperspecialization, or doubling down in similar academic disciplines, significantly decreases breadth of knowledge in a range of academic domains. This approach to double majoring will be more concentrated—a circumstance shown to be somewhat problematic by the extant research on liberal arts outcomes—than either single majoring or choosing majors in different disciplinary categories.

Data and Methods

In order to operationalize breadth/concentration in a student's undergraduate career, we collected a sample of 240 undergraduate transcripts from students who attended more than 140 universities throughout the United States. The transcripts were randomly selected from a sample of nearly thirteen thousand graduate school (i.e., not law, medicine, or business) applications at an American Research I university. The sample was made up of subjects who specialized or declared a single major, hyperspecialized or declared two similar majors, and hypospecialized or declared two unrelated majors. The composition of specialized subjects was as follows: natural science (n = 30), humanities (n = 30), and social science (n = 30) majors. Double major combinations are organized as so: two natural sciences (n = 16), two social sciences (n = 20), two humanities (n = 22), natural science and social science (n = 16), natural science and humanities (n = 17), and social science and humanities (n = 19).[5] To account for professional majors, engineering (n = 20) and business (n = 20) transcripts were included as well.

Analyzing college transcripts is an innovative way to assess educational history and uncover patterns and nuances with respect to course and major selection, which proves to be key to a general education curriculum. Although the transcripts were collected via our convenient access to graduate applications at one university, there are benefits to our sample selection process.[6] First, the transcripts represent more than 140 colleges and universities, rather than typical transcript analyses that—also out of convenience—pull only from experiences at one or two institutions. Second, while the subset of undergraduate majors used in this analysis was constrained to five major domains, the

transcripts were drawn from a broad pool of applications to more than fifty graduate programs. For example, English majors were not necessarily applying for graduate degrees in English. In fact, nearly one-third of the final set of two hundred natural science, humanities, and social science transcripts was from applicants pursuing graduate degrees different from their undergraduate program. Selecting applications to a broad range of advanced degrees minimized the possibility that students' courses were selected with plans to pursue particular humanities, natural science, or social science graduate degrees.[7] By the most conservative estimate, then, this sample is at least representative of the 32 percent of U.S. undergraduate students who apply to graduate programs at research universities.[8] However, we contend that the sample is generalizable beyond students interested in graduate school because our data represent course selection throughout students' tenure—from the summer of their first year through the seventh semester—and likely represent many decisions made prior to and outside of any strategy for pursuing an advanced degree.

Key In/Dependent Variable: Academic Concentration

The major variable used in this analysis was a measure of concentration in students' college course selection. We coded every course completed by semester and categorized them into the nine domain-of-knowledge classifications most commonly found in college and university core curricula: artistic expression, literary criticism and composition, foreign languages and culture, historical consciousness, moral and philosophical reasoning, scientific inquiry, quantitative literacy, social analysis, and diversity/global studies. Researchers worked together to code every transcript, and any discrepancies were cross-checked using course descriptions from university catalogs for reliability. As discussed earlier, these nine classifications were drawn from those most consistently used by universities. This approach enabled us to ground our analysis in the norms of the field of higher education rather than some more abstract, and ultimately less reliable, approach to classifying knowledge.

In order to measure breadth among these domains of knowledge, we used the Herfindahl-Hirschman Index (HHI) as our dependent variable. The HHI is a measure of the concentration of firms in a given market often used by economics and business scholars (Rhoades, 1993, 1995). The HHI has been adopted to measure a variety of concepts intended to gauge diversity within a specific area and is calculated in essentially the same manner as other common diversity indexes (Tabner, 2007), such as the Simpson's Diversity Index (Simpson, 1949). The HHI has been adapted to measure religious competition (Ellison, Burr, & McCall, 1997; Rose, 2000), racial heterogeneity (Johnson, Crosnoe, & Elder, 2001; Sampson, 1991), private-public school competition (Belfield &

Levin, 2002), and concentration of academic citations (Larivière, Gingras, & Archambault, 2009). To our knowledge, this is the first time this index has been used in higher education research. Consistent with other social science literature, we chose the HHI because it provides a reliable and uncomplicated equation to determine concentration levels; the higher the HHI, the more concentrated a student's course load is in particular domains of knowledge.

The HHI is the sum of the squares of the market share of each firm (or in our case, domain of knowledge), measured as

$$\mathrm{HHI} = \sum \left[(x\,(i)\,/x)^2 \right]$$

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 considered 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 us take, for example, two students who 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, yielding a 0.1 HHI score. In other words, student A was highly concentrated, whereas student B had total breadth. The higher the HHI, the less breadth across the domains of knowledge a student has. Obviously, the index's technical range of 0 to 1 assumes extremes that are unlikely to exist in any actual market. We expected our analysis to uncover a more plausible, if not completely practical, range for this score as an academic concentration measure. More specifically, using this to measure major concentrations provides a greater understanding of majors in terms of market shares for the domains of knowledge that are central to general education.

We argue that this index is superior to a simple tally or even percentages of courses for two significant reasons. First, a simple tally of courses would only give us a count, which varies based on the number of courses it takes the average student to finish a chosen curriculum. We believe that a better approximation—at least in terms of determining domain-specific concentrations—involves the percentage shares provided by the index. Second, and more importantly, while percentage shares and course tallies allow us to determine course concentration *within* each domain, the Herfindahl-Hirschman Index allows us to determine course concentrations *across* the nine domains.

Table 2 shows both the HHI index scores and domain-of-knowledge percentage shares for the various specializations.[9] Two-tailed t-tests were used in the

first two columns—mean course counts and HHIs—to determine whether single majors specializing in either the humanities (row e), social sciences (row h), or natural sciences (row k) differed from students with either two majors in that disciplinary cluster (rows f, i, and l, respectively) or a major in that cluster and one of the other two (rows g, j, and m, respectively). The numbers listed under the nine domains of knowledge and a miscellaneous category indicate the average percentage of each domain represented in each set of students' curricula. For example, 11.0 percent of the courses English single majors (specialists) took were in the historical consciousness domain, while only 5.4 percent of the courses biology single majors (specialists) took were in that domain.

Other Dependent, Key Independent, and Control Variables

For ordinary least squares analysis examining concentration as a *dependent* variable (Table 3), we controlled for student characteristics, institutional characteristics, and course characteristics. Controls for student characteristics were used to account for other opportunities to gain academic breadth, such as a minor or study abroad experience (1 = *yes*). We were also able to obtain each subject's gender (1 = *yes*) but did not have information on any other demographic characteristics. Course characteristics were controlled to account for variations within students' collegiate tenure. We included continuous variables for total number of precollege (e.g., advanced placement [AP]) courses/credits,[10] as well as the number of courses students took once matriculated. Finally, we controlled for institutional costs (i.e., a continuous measure of tuition and fees), which could potentially place constraints on the number of courses a student takes.

Results

Specialization: Single Majors and Course Concentrations

The first aim of this analysis is to show how liberal arts knowledge is being accumulated by students who graduate with only one major, those we call "specialists." This specialization can be observed in Table 2, rows c, d, e, h, and k. Again, 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 natural sciences and social sciences. As the first row (labeled "Liberal Arts Core") of Table 2 reveals, the lowest HHI a student could likely attain is 0.107 because of the general education requirements on most campuses; no student could be totally concentrated in any one domain. Similarly, because each student has to have at least one major, which by its nature is going to lead to some specialization, no student could have total breadth either.

Table 2 | Liberal Arts Domains of Knowledge, Course Counts, and Herfindahl-Hirschman Index (HHI) for Key Student Curricula.

Student Curriculum	*Mean Course Count*	*Mean HHI*	*Liberal Arts Domain of Knowledge (Percentage Share)*									
			ARTS	*READ*	*HIST*	*LANG*	*MORL*	*SCIE*	*MATH*	*SOCS*	*WRLD*	*MISC*
a. 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
b. All arts and science majors	37.61	0.288	3.4	16.6	6.7	7.1	5.4	24.1	6.5	21.1	3.4	5.6
c. Engineering majors	40.50	0.504	0.8	4.4	2.1	0.3	3.0	68.4	12.3	4.3	0.2	4.2
d. Business majors	38.75	0.264	3.9	5.2	5.9	10.2	4.7	4.6	18.0	39.5	0.5	7.5
Humanities Majors												
e. 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
f. Hyperspecialization	37.77*	0.240	3.5	37.2	8.9	9.8	12.3	5.3	3.0	5.3	6.8	8.0
g. Hypospecialization	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												
h. 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
i. Hyperspecialization	36.13	0.375***	1.3	4.5	5.5	5.4	5.0	7.5	5.6	57.4	3.0	4.9
j. Hypospecialization	37.67*	0.260	4.0	13.4	3.9	7.1	4.2	19.8	7.1	31.8	3.3	5.4
Natural Science Majors												
k. Specialization	40.53	0.348	2.4	5.8	5.4	4.4	3.2	54.3	9.4	6.6	3.3	5.1
l. Hyperspecialization	42.44	0.408*	4.1	4.1	4.8	2.1	4.6	60.9	8.6	4.1	1.5	5.2
m. Hypospecialization	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												
n. Humanities and 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
o. Social science and natural 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
p. Natural science and humanities	41.18	0.267	8.3	16.3	3.4	9.0	7.2	34.6	8.3	5.8	2.2	4.9

Note: See Table 1 for domain-of-knowledge abbreviations; MISC = miscellaneous. Statistical significance of course counts and HHI were determined by two-tailed *t*-tests comparing specialization (e, h, k) to either hyperspecialization (f, i, l) or hypospecialization (g, j, m). A higher HHI indicates less breadth in students' courses.

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

Table 3 | Ordinary Least Squares Regression Predicting the Herfindahl-Hirschman Index (Single Majors Are the Comparison Group).

Variable	*Total Sample*		*Humanities*		*Social Sciences*		*Natural Sciences*	
Double majors								
All	0.007		0.003		0.036		−0.034	
Hyperspecialized		0.038*		−0.008		0.100***		0.058*
Hypospecialized		−0.032**		0.012		−0.015		−0.091***
Female (1 = *yes*)	0.002	0.005	−0.002	−0.006	0.026	0.012	0.001	0.008
University tuition	−0.000*	−0.000	−0.000	−0.000	−0.000**	−0.000**	−0.000	−0.007
Academic minor (1 = *yes*)	−0.021	−0.017	0.020	−0.002*	−0.047*	−0.060**	−0.024	−0.000
Study abroad (1 = *yes*)	−0.028*	−0.025	−0.019	−0.018	−0.031	−0.015	0.019	0.029
Total precollege courses	0.002	0.003	0.002	0.018	0.004	0.006**	0.001	0.003
Total courses	0.001	0.001	−0.002*	−0.002*	−0.005*	−0.003	0.001	0.000
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
Number of cases	200	200	88	88	85	85	79	79

Note: Column I (in each model) is the effect of any double major combination and column II (in each model) is the effect of specific types of combinations.
* $p < .05$; ** $p <. 01$; *** $p < .001$

Specialization—independent of the area(s) or type of specialization—is always going to decrease breadth beyond 0.11, as the rest of the table shows. With a wide range of 0.15 to 0.60, the mean HHI score is 0.29 for our sample of two hundred arts and science majors (row b). These numbers suggest a potential floor and ceiling for this measure of concentration in academic domains of knowledge. They also show that students, on average, are closer to achieving balance (lower HHI) than concentration (higher HHI) with their course selections.

However, further exploration reveals more important patterns. Probably the most notable finding is the high course count and concentration of natural science and engineering majors. Natural science single majors (row k) have a mean HHI score of 0.35, and over 54 percent of their courses fall into the scientific inquiry domain. Relatedly, engineering majors (row c) have an even higher concentration (HHI = 0.50), with over 68 percent 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 (row d) have an HHI score of 0.26; humanities single majors (row e) have an HHI score of 0.26; and social science majors (row h) have the lowest measure of concentration among single majors, with an HHI score of 0.25. Looking at the liberal arts domains' percentages, we can see that, unlike for the engineering majors, none of the domain percentages dips below 2 percent for business, humanities, and social science single majors. For instance, eight of the ten domains for social science majors have percentage shares between 4 percent and 10 percent. Compared with the other single 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 have detailed, some students graduate with double majors and are, therefore, becoming either more or less specialized. Therefore, we also focus on differences between single and double majors. 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). Hypospecializing double majors are less concentrated because they, undoubtedly, have fewer courses in any one field of study and this enables students to engage a broader range of courses and domains of knowledge. Alternately, hyperspecializing double majors are more concentrated because the two fields are related (at least in terms of divisional cluster) and courses, presumably, have some overlap in the knowledge they cover.

Collectively, single majors are neither more nor less concentrated than double majors. It is only when we look at the direction of double major specializations that differences in concentration are revealed. Double majors who hyperspecialize are the most concentrated, with an HHI of 0.33 (t = −3.25; p = .001). Conversely, double majors who hypospecialize have a significantly lower HHI of 0.26 (t = −4.14; p = .000). Specialists (HHI = 0.28) lie between these poles; their HHI was significantly higher than that of hypospecialists (t = −4.22; p = .000) and lower than that of hyperspecialists (t= −3.42; p = .000). Taking required and elective courses for two majors in nonoverlapping fields creates more diversity among courses. Conversely, taking required and elective courses for two majors in similar fields creates more course concentration.

In Table 2, we can also see how course concentrations differ by hyper- and hypospecialization in specific liberal arts fields. Generally, humanities majors have the lowest concentration of domains. Moreover, there are no significant differences in breadth among humanities majors who specialize (row e: HHI = 0.26), hyperspecialize (row f: HHI = 0.24; t = 1.19; p = .241), or hypospecialize (row g: HHI = 0.25; t = 0.23; p = .816). In contrast, as in engineering, majoring in a natural science is associated with high concentration. As indicated previously the HHI score for science specialists (row k) is 0.35; science hyperspecialists (row l: HH1 = 0.41; t = −2.44; p = .019) are even more concentrated. It should be noted that when science majors choose dissimilar second majors, they become significantly less concentrated (row m: HHI = 0.27; t = 3.53; p = .001) than their single major counterparts. Examining course selection among social science majors reveals a complex pattern. Again, social science specialists have more breadth (row h: HHI = 0.25) than either humanities specialists (t = 2.27; p = .028) or natural science specialists (t = 3.69; p = .001). Social science hypospecialists have similarly low levels of concentration (row j: HHI = 0.26; t = −0.75; p = .456) as specialists. However, hyperspecialists in the social sciences are highly concentrated (row i: HHI = 0.38; t = −5.46; p = .000) and significantly different from their single-majoring peers.

Single Majors and Double Major Concentration Outcomes (with Covariates)

Considering the various distinctions between single and double majors, in general and within core distinctions, we examined multivariate correlations. In the next portion of our analysis, we regressed the Herfindahl-Hirschman Index on specialization type (with single majors/specialists being the excluded group), controlling for total courses, total precollege credits, gender, minor, study abroad experience, and tuition. These results can be found in Table 3.[11]

Sensitivity analysis suggests that the inclusion of these covariates did not affect the direction and relationship between majoring and academic breadth.

Our main focus is to explore the relationship between course breadth and major selection. Examining the R^2, a measure of the amount of variation explained, reveals that the hyper/hypospecialization distinction increases the explanatory power of each of the models; grouping all double majors together limits the conclusions one can make. The positive association between hyperspecialization and concentration and the negative association between hypospecialization and concentration is one reason for the greater explanatory power. Once any effects of student characteristics and number of precollege and college courses are parceled out, the regression analysis confirms what we described earlier. The first column of Table 3 shows that hyperspecialists are more concentrated than specialists by 0.038 ($p < .05$) units on the HHI and hypospecialists are less concentrated by 0.032 ($p < .01$) units.

The second column presents results of the humanities sample. Holding the controls constant, no significant differences between the degrees of specialization are revealed. In the next column, however, we see that hyperspecialists in the social sciences have a significantly higher concentration, by 0.10 ($p < .001$) units, than specialists. Finally, the last column presents results from the natural 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 hyperspecialization and concentration; hyperspecialists are 0.058 ($p < .05$) units more concentrated. Hypospecialists, on the other hand, are significantly less concentrated than specialists by 0.091 ($p < .001$) units. These regressions confirm the bivariate findings that type of specialization impacts concentration in different ways.

Discussion and Conclusions

In this article, we examine the relationship between academic specialization and student exposure to a range of academic domains of knowledge. We found that major selection is associated with variance in level of exposure to domains of knowledge, with hyperspecialization posing the largest threat to breadth across academic fields. Moreover, our findings reveal notable patterns in academic specializations that may pose real consequences in terms of human capital accumulation and a truly broad-based general education, whether students major in the liberal arts or the practical arts.

First, we found differences in the ways professional 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, it is clear that concerns raised about the "practical arts" are only

partially warranted. Business specialists, 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 or humanities specialist. We argue that other professional specialties, such as communications and education, would be similar in terms of breadth. Conversely, the average engineering major is exposed to virtually no liberal arts knowledge beyond that taught in natural science courses. If one considers that most of their liberal arts 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, such as nursing and agricultural production, likely suffer from the same impediment. The trend toward academic concentration we expose in engineering is seen more pervasively on 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. When these students hyperspecialize in the sciences, adding a second major in another science, their exposure to courses that 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 both scholars and institutional leaders are right that 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 hyperspecialization in the natural sciences can also be observed in the social sciences. Social science majors are uniquely situated in terms of breadth. Social science single majors take as equal a share of courses across the nine domains as humanities single *or* double majors, in spite of the fact that five or six of the domains fall into the humanities core. This is a function of the competencies in history, foreign languages, composition, and quantitative literacy required by many social science fields. For example, 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 them a particularly potent (in terms of adding breadth) addition to either a humanities or natural science major. In both cases, the student's course load becomes less concentrated when combined with a social science major; this is especially true for students who already have a natural science major.

While hyperspecialization has a negative impact on social science and natural science majors' exposure to a broad range of academic knowledge, students' hyperspecialization 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 that of 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 hypospecialization uncovers two different dynamics at work. In both scenarios, the number of courses increases. However, if English majors add history as a second major, the course changes are minor ones. They simply take slightly fewer literary criticism/composition courses and slightly more historical consciousness courses than they would take as English single majors—suggesting slightly less overlap existing between humanities courses than there might be in social science or natural science courses. Alternately, when English majors add physics as a second major, there is little overlap between the two majors, so students have to take more courses to fulfill each major's requirements. 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.

This trend has a very important implication: when students double major in a humanities field and add either a social science or natural science field, the *primary* driver of course-taking priorities appears to be the social or natural science one. This is especially the case for natural science majors, for which there is virtually no overlap with either the humanities major or the liberal arts core requirements. Of the three core divisions in the arts and sciences, the humanities suffer most in terms of market share when students either hyper- or hypospecialize. This problem is heightened by the fact that many students are able to double major because they arrive with enough AP examination credits to free them from "core curriculum" requirements (Pitt & Tepper, 2013). This poses a particular threat to the humanities. Given student demands for AP credit in literature, composition, history, and foreign languages, many double majors in natural and social sciences may avoid college exposure to these domains altogether.

We agree with Del Rossi and Hersch's statement that "the variations in skills provided by specific combinations of majors may have a productivity effect rather than merely a signaling effect" (2008, p. 382). Our measure of concentration of domains of knowledge, essentially a measure of the variation in skills provided by a student's undergraduate curriculum, allows us to more definitively declare that what we find on students' *transcripts* is as much a factor in their postbaccalaureate success as what we might find on their *diplomas*. The benefits Kanter (1983) describes in her prescription for innovation are not just a function of having multiple majors; they come as a result of having

multiple lenses through which to view problems. Hypospecialization through double majoring may be the mechanism whereby these lenses are acquired.

Research suggests that nearly a third of double majors are choosing fields located in similar core areas; they are hyperspecializing (Pitt & Tepper, 2013). If hyperspecialization is negatively correlated with one major aim of higher education institutions—breadth of knowledge—what impact might it be having on others? Are hyperspecialists at a disadvantage in terms of being able to think analytically, develop intellectual curiosity, or gain the intellectual habits that will enable them to become lifelong learners? The remaining two-thirds of double majors, the hypospecialists, have as much breadth as, or more than, 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 have been exposed to? Benander and Lightner (2005) suggest that there are ways to promote a transfer of learning across courses, but are there other ways that double majoring in dissimilar fields may be benefiting these students?

Though these questions still remain, this article clearly identifies the types of exposure to different domains of knowledge that are associated with different academic specializations. Unique to this research is the use of the HHI to identify how these different academic specializations function similarly to market shares, allowing us to determine just how equitable certain majors and double major combinations are when it comes to the domains of knowledge. For example, we find that certain double major combinations have costs and/or benefits with regard to the domains of knowledge that a general education is supposed to be exposing its students to. Specifically, majors such as language might suffer heavily if it were not for the option to double major in higher education. In fact, selecting a foreign language as a major is almost always chosen with a second (i.e., extra) major (Pitt & Tepper, 2013). It is quite plausible that without double majors, the language major might just disappear. And as many students acknowledged in Pitt and Tepper's (2013) focus groups, a primary value of the extra major is still an economic one: that majoring in a foreign language may help them be more competitive candidates for furthering their education (e.g., medical school; see Guertin, 2015, for more) and subsequently aid in securing a job upon graduating. Thus, hyperspecializing may contribute to a substantial drop in the market shares of the domains of knowledge, since some domains are barely included within certain double major combinations.

In some cases, or in some major selections (single or double), students are being exposed to a broad range of the domains of knowledge, while other selections are limiting the domains of knowledge a student has exposure to. If general education is supposed to be based on broad exposure, then we are failing a

number of students by not requiring a more integrated approach to the domains of knowledge in all major selections and combinations. In other words, some students might not be getting the liberal arts education that they expect when they choose to pursue a liberal arts curriculum. This is especially problematic when we consider the differential majoring patterns across social demographics such as race, class, and gender (Goyette & Mullen, 2006; Jacobs, 1986, 1995). It may be the case that students who might benefit from increased exposure to different ways of thinking (e.g., white males) are opting into majors that do not encourage breadth. Even more so, issues of specialization are important to understand as chairs and deans review major curriculum and the different requirements associated with various university departments. If the goal of higher education institutions is to produce well-rounded graduates who have accumulated the kind of broad-based human capital that ultimately pays off in economic terms, institutions must work to promote breadth in all majors and encourage all students to integrate their areas of study. The production of well-rounded graduates not only reinforces the core beliefs of general education—breadth among the domains of knowledge—but should also lead to well-rounded employees as these graduates move from university into the workforce.

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NOTES

1. Only 35 percent believe that 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 institution (e.g., freshman seminars) or train them in practical lifestyle 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. This number, like the percentages shown in Table 1, is based on the coding of our random sample of baccalaureate, master's-granting, and doctoral-granting institutions' course catalogs with any general education requirements. It is confirmed in the course counts ($X = 12.34$) for the liberal arts core shown in Table 2, row a.

5. Specifically, we selected transcripts from students with at least one of the following majors: biology (natural 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 240 cases.

6. We recognize that this limits our findings' generalizability to undergraduates who apply to graduate school, but as we explain, the population our sample was randomly drawn from (within disciplinary sets) included students who applied to graduate programs similar to and quite different from their undergraduate majors.

7. We tested this possibility using *t*-tests of the mean concentration level for those applicants pursuing similar B.A./Ph.D. degrees and for those pursuing different degrees. The mean level of concentration for applicants pursuing similar degrees was 0.289, and the mean for those pursuing different degrees was 0.273; the seeming difference was statistically insignificant ($p = .2357$).

8. The 32 percent figure is from the National Center for Education Statistics *Baccalaureate and Beyond* 2012 data and power stats.

9. The data in Table 2, row a, "Liberal Arts Core," were derived by coding the general education requirements for each school represented in our student sample and then determining average requirements for all 240 students.

10. This includes course credit gained through International Baccalaureate coursework, community college courses taken before matriculation, and (most commonly) AP exams.

11. The primary dependent variable for this analysis is each student's HHI, a continuous variable. The distribution of the HHI approximates a normal distribution as evidenced by kernel density and normal density plots. These tests—plotted for each regression—indicate that any errors are independently distributed with a mean close to zero and slightly more variance, with no extreme outliers or bimodalities, in the left tail of the distribution. These plots are available by request.

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