Have Union Students Become More T-Shaped?

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1. Abstract

Interdisciplinary study benefits college students by giving them perspectives and ways of thinking that are influenced by a variety of disciplines. College administrators thus have a goal of developing programs and requirements that give students an interdisciplinary education, making them more "T-shaped" (broad and deep) rather than merely "I-shaped" (deep). The breadth of courses that students take constitutes part of what it means to be T-shaped. Aside from a student's major requirements and General Education requirements, students choose up to half of their courses as free electives, leaving a significant amount of room for them to explore different disciplines. This project asks whether or not students are more T-shaped now than they were in the past. I obtained data by scraping all of the college's course roster pages since the fall of 2001. For each student who has graduated since the class of 2005, information from all of their completed courses is used to evaluate the average student's level of interdisciplinary study over time. This is measured by the breadth of courses each student took: the number of unique departments represented on their transcript. My results show that students have taken courses in a greater number of unique departments, suggesting they have become more interdisciplinary, or T-shaped.

2. Introduction

One contributor of economic success is human capital: a measure of the value of a person's skill set. This skill set includes the person's education, experiences, and abilities. Educational institutions, including colleges in particular, are a means of accumulating human capital. While some human capital accumulation happens outside of the classroom, most of it takes place in the context of the courses that students choose or are required to take.

Major is an important part of the college education, but major makes up as little as one third of the courses that students take while in college. There is surprisingly little work done on how students go through the college curriculum and choose courses. The options that are presented to students by the college curriculum are important for all colleges looking to provide the best education for their students. For this reason, an ideal model of how students navigate the curriculum would be beneficial to colleges when creating academic programs and requirements. This paper examines one dimension of students' course selections: their breadth of study. More specifically, this paper looks at whether or not students have become more interdisciplinary.

Interdisciplinary study is defined as a process seeking to synthesize broad perspectives, knowledge, skills, and interconnections in an educational setting. Interdisciplinary study in college curricula has received increasing attention over the past couple of decades. Boix Mansilla and Duraisingh (2007), Lattuca, Voigt and Fath (2004) and others support the view that young people benefit from developing perspectives and ways of thinking that are influenced by a variety of disciplines. This interdisciplinary core is thought to provide a successful foundation for entering professional life and serves as an important vehicle for contemporary knowledge production.

In particular, Leonard and Sensiper (1998) among many others argue that innovation and entrepreneurship is fostered by taking interdisciplinary approaches to problems. This makes students who have an interdisciplinary education more likely to succeed as innovators and entrepreneurs. Donofrio, Sanchez and Sproher (2009) make the case that "T-shaped" individuals (those who are both broad and deep) are more valuable in the workplace than just deep "I-shaped" individuals. Therefore, we can argue that it is better for colleges to produce T-shaped students rather than I-shaped students.

Furthermore, colleges that offer more interdisciplinary programs are shown by André (2001-2002) to be particularly attractive to women and underrepresented groups. Therefore, stressing interdisciplinarity provides a way of attracting and retaining those groups, something that colleges strive to do.

Being a liberal arts school, Union especially strives to give students a broad, interdisciplinary education. This paper asks whether or not students are more interdisciplinary, or T-shaped, now than in the past. While breadth of education is not the only thing that constitutes an interdisciplinary education, it is one dimension of interdisciplinarity. In asking this question, I am curious to know if students themselves have chosen to pursue a more interdisciplinary education or if other factors may have affected any change in the breadth of courses that students take. The answer to this will give insight into the degree to which interdisciplinarity may be driven by academic programs and curriculum requirements as opposed to student choice.

The relationship between academic requirements and students' freedom of course selection can be thought of in a couple of different ways. On one hand, more requirements could ensure that students get a certain level of a broad education (assuming the requirements include breadth) because they are forced to meet a minimum in order to graduate. On the other hand, more requirements leave students with fewer courses to choose from on their own, thus limiting the breadth of courses that they might choose to take even if there were no requirements. In this way, more requirements might not necessarily lead to students taking broader courses.

3. Related Work

3.1 Major/Subject Choice and Occupation Choice

Although curriculum choice is not a new topic of research, most of the existing literature pertaining to curriculum choice has to do with choice of specific major or subject. Many papers try to find determinants of a student's college major. For example, Berger (1988) and Montmarquette, Cannings, and Mahseredjian (2002) find that students are more likely to choose one major over another if the predicted future earnings stream of that major is relatively greater. Also, research such as that of Malgwi, Howe and Burnaby (2005) suggest that gender, interest in the subject, experience, skills, predicted earnings and career opportunities are also determinants of the major a student chooses. In addition, Porter and Umbach (2006) find that political views and personality traits significantly determine college major choice.

Aside from college major choice, there have also been similar studies that look at subject choice in general, regardless of major. Fournier and Sass (2000), for example, make some interesting conclusions pertaining to the effects of class size, faculty grading, and faculty quality on the likelihood of a student taking economics courses past introductory courses. Similarly, Ashworth and Evans (2001), explore factors that influence the likelihood of a student choosing to take any economics courses. They find that mathematical ability, prior study of economics, achievement in economics, and certain features of the classroom environment affect the likelihood of a student choosing to take economics courses.

Similar to choice of major is choice of occupation, which there is also a significant amount of literature on. Like the literature on major choice, many papers on occupational choice focus on what influences a person's choice of any particular occupation. Ham, Junankar, and Wells (2009) examine the effect of an individual's personality traits and status of their parents on the likelihood of them having a white collar occupation as opposed to a blue collar occupation. Additionally, Miller (1984) discusses how people go about choosing occupations and changing jobs throughout their career. Although this research does not directly relate to curriculum choice, choosing jobs and career paths can be paralleled to choosing courses and curriculum paths.

3.2 Choice Architecture

Curriculum choice is related to a newer, increasingly popular literature on consumer choice in complex environments. In their book, Sunstein and Thaler (2008) talk about how decision-making is influenced by the choice environment. They show how choice architecture

can be used to help nudge people to make better choices without forcing any outcomes. This relates to curriculum choice because the college's programs and requirements contribute to the student's choice environment when choosing what courses to take. Johnson et al (2012) build on this by talking about various tools that can aid a choice architect (anyone who presents people with choices) in structuring a choice task and describing choice options. For example, they address the problem of deciding how many alternatives to present to the decision maker. Sometimes there can be too few options to choose from (e.g. a product only being offered in one color) but there can also be too many options, resulting in choice overload (e.g. hundreds of options of retirement plans). This relates to the study of college curriculum programs and requirements because they are aspects of the choice environment faced by student consumers as shaped by the program choice architects (faculty and administration).

Scott-Clayton (2011) is one example of a paper that uses this theory of choice architecture to evaluate curriculum choice; in particular, the author examines the role of program structure in student persistence. The paper explains that community college students are better able to navigate through a curriculum successfully when there are tightly structured programs that give students little room to deviate from paths toward degree completion. Therefore, it relates to work on curriculum choice because it talks about the ways in which students navigate through a curriculum when there are different sets of choices available to them.

3.3 Interdisciplinarity

In addition to the previously mentioned literature on the importance of interdisciplinary study in a broad sense, there has also been some work that focuses on the interdisciplinarity surrounding individual courses. For example, Caviglia-Harris (2003) talks about the benefits of interdisciplinary introductory courses in providing students with an opportunity to learn about how more than one discipline can fit together in one topic. Also, Boix Mansilla and Duraisingh (2007) talk about assessment methods for individual interdisciplinary coursework. However, the literature does not have a big focus on interdisciplinary study over the entire undergraduate curriculum.

There is also past literature pertaining to "learning communities", which include elements of a cohort-based, interdisciplinary approach to higher education. Zhao and Kuh (2004) are among others who discuss learning communities in this way. One interesting form of a learning community is one that is made up of students co-enrolled in two or more courses (often from different disciplines) that are linked by a common theme. In this way, learning communities emphasize interdisciplinarity.

3.4 Using Transcript Data

There are very few previous studies that have used transcript data to answer research questions, which is similar to using course roster data such as used in this study. Hagedorn and Kress (2008) describe how researchers could use college transcript data to understand college students' success in completing a degree. With all of their examples, however, grades are an important part of the research. This paper, on the contrary, does not use grades; only course roster data is used.

4. Methods

4.1 Getting the Data

The main source of data for this project came from the Union College course roster web pages. For each course offered at the college, there is a course roster page that holds information about the course and about each of the students who completed the course. Links to these course rosters are only available to faculty, directly through the public course schedule pages that list all courses offered from each department for a given term/year (see Figure 1). I used the enrollment information contained in all course rosters from 2001 to 2012 – amounting to over 28,000 course roster pages.

To get the data all in one place and in manageable format, I wrote a Python script to scrape all of the data from each course roster page and put it into a new data file. The Python script does this in four main steps:

1. Takes a list of years, terms, and departments (created manually) and locally saves each public course schedule page that exists for each combination of year, term, and department (e.g. 2012, Fall, Computer Science). Since each page has a common URL structure – for example "http://www.union.edu/applications/course-schedules/12.FA.CSC.html" where '12.FA.CSC' denotes the year, term, and department – the pages are easily obtainable.
2. Using the public course schedule pages obtained in step 1, gets the name of each course offered (and in what term and year) by scraping the course names from each of the saved course schedule pages. A list of all of these course names is saved to a local file.

3. Using the list of course names obtained in step 2, each corresponding course roster page is saved locally (again, made possible by a common URL structure). For example, when scraping the public course schedule page shown in Figure 1, this step saves the course roster page for "Taming Big Data W/ Lab", the course roster page for "Game Development: Intro to CS", and so on. Since the private course roster pages are password-protected, Python's *mechanize* package was used to browse the pages given a username and password.
4. For each course roster page, scrapes the data and appends it to one spreadsheet in CSV (comma-separated values) format. During the scraping process, students' names were replaced by random ID numbers to retain privacy. This was done by using a dictionary:
    - If a student's name was not already in the dictionary, then a random number (also not already in the dictionary) was generated in place of the student's name and the student/number pair was then added to the dictionary.
    - If a student's name was already in the dictionary, then the existing corresponding ID number was used to replace the student's name.

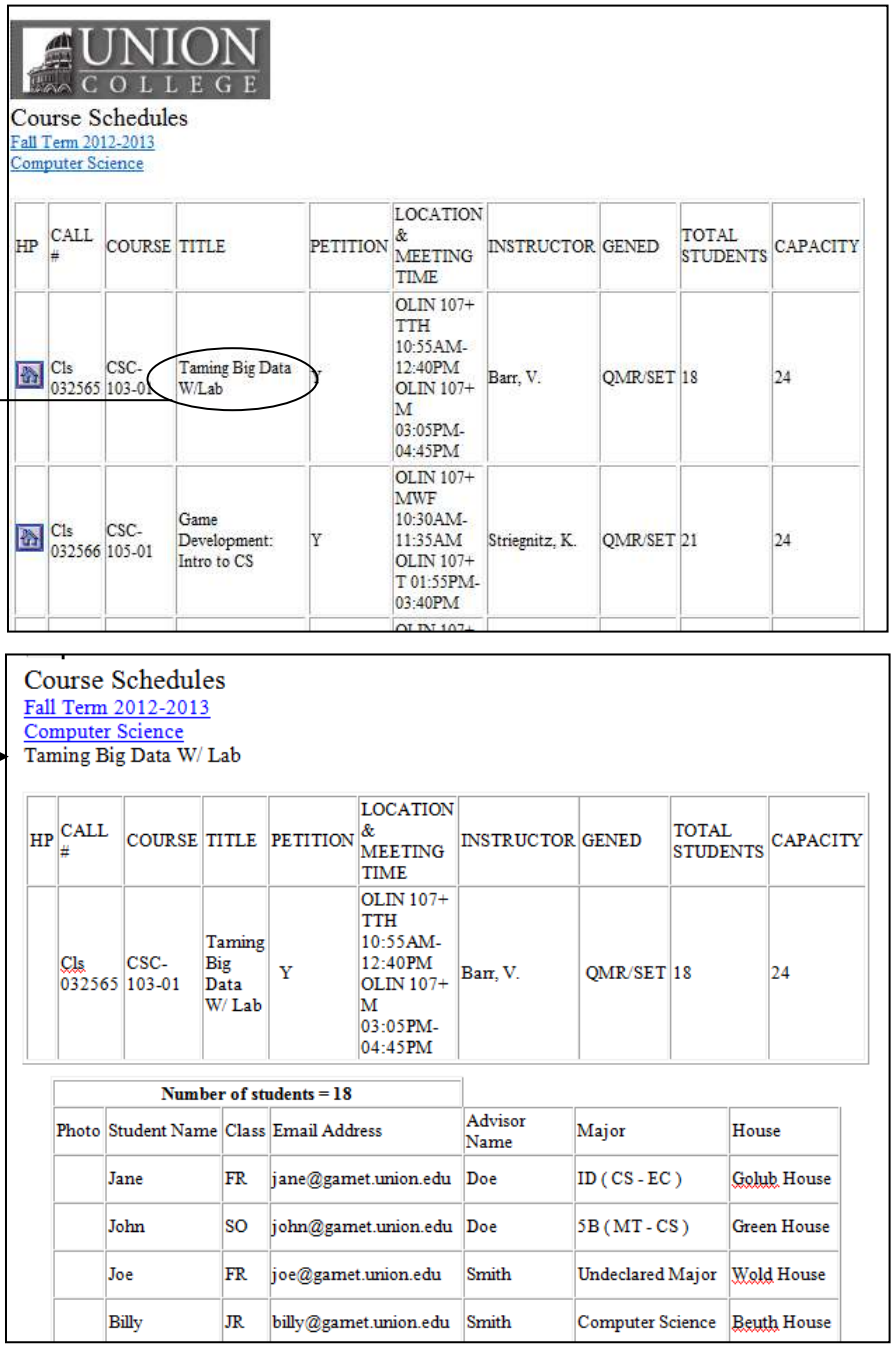
    In this way, no students' names were written to the spreadsheet, only the random ID number unique to each student.

The final spreadsheet contained information about each student that has attended the college since 2001, including a random identifier (ID number), their major, and course enrollment information including the course name, department, year, term, and the student's year of study at the time of completing the course. No personal information (names, photos, or email addresses) were used.

The spreadsheet was then imported to Stata, a statistical software package. In Stata, I was able to organize, manipulate, and analyze the data to obtain interesting results. For example, I was able to create new variables based on existing variables (e.g. a student's graduating class year as a function of their year of study and term/year) and calculate various statistics by groups of variables (e.g. students of the same class year).

Figure 1

Sample Public Course Schedule Page (top) and Private Course Roster Page (bottom)



UNION COLLEGE

Course Schedules

Fall Term 2012-2013

Computer Science

HP	CALL #	COURSE	TITLE	PETITION	LOCATION & MEETING TIME	INSTRUCTOR	GENED	TOTAL STUDENTS	CAPACITY
	Cls 032565	CSC-103-01	Taming Big Data W/Lab	Y	OLIN 107+ TTH 10:55AM-12:40PM OLIN 107+ M 03:05PM-04:45PM	Barr, V.	QMR/SET	18	24
	Cls 032566	CSC-105-01	Game Development: Intro to CS	Y	OLIN 107+ MWF 10:30AM-11:35AM OLIN 107+ T 01:55PM-03:40PM	Striegnitz, K.	QMR/SET	21	24

Course Schedules

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Taming Big Data W/ Lab

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Number of students = 18						
Photo	Student Name	Class	Email Address	Advisor Name	Major	House
	Jane	FR	jane@gamet.union.edu	Doe	ID (CS - EC)	Golub House
	John	SO	john@gamet.union.edu	Doe	5B (MT - CS)	Green House
	Joe	FR	joe@gamet.union.edu	Smith	Undeclared Major	Wold House
	Billy	JR	billy@gamet.union.edu	Smith	Computer Science	Beuth House

4.2 Describing the Data

I define department as being any three-letter prefix in the "course" section of the course roster. For example, philosophy courses are listed as "PHL-xxx-yy" where PHL is the department, xxx is the course number, and yy is the course section. Note that department is not necessarily the same thing as major or program. For example, a student majoring in managerial economics does not take any courses from a managerial economics department because there is no such department; they take courses from the economics department. Similarly, I consider Chinese and French to be departments because Chinese and French courses are listed as "CHN-xxx-yy" and "FRN-xxx-yy", however Chinese and French are technically not departments in the college's sense of the word; they are programs within the modern languages department.

Since the earliest enrollment information I had was from fall of 2001, the graduating class of 2005 was the earliest graduating class for which I had complete information for (course enrollment information for their full four years at Union). Thus, my analysis begins with the class of 2005 and ends with the class of 2012.

Some of the data was taken out of the dataset for the purpose of achieving a more accurate analysis. First, dance and music practica were removed from the dataset because they do not count as a full course credit (in most cases only 1/3 of a course credit) and can be taken in addition to a regular course load. Other departments' practica were kept in the dataset. Additionally, labs were removed from the dataset (any course listed in the form "DPT-xxxL-yy" where 'L' denotes a lab). The regular courses corresponding to those labs were kept in the dataset. Also, students who did not attend the college for four to five years were removed from the dataset, leaving out transfers and other students in special circumstances. For all course roster entries, if the student's name was not listed as being a freshman, sophomore, junior, senior, or degreed (meaning they graduated) then the student was taken out of the dataset, leaving only undergraduate students while removing masters, post-grad, post-undergrad, non-degree, and non-matriculated students.

Table 1 shows some descriptive statistics of the full dataset, showing totals and averages taken from 2001 to 2012.

Table 1

Descriptive Statistics, 2001-2012

Number of students	4,113
Average Number of Students per Class	514
Number of courses[1]	16,019
Number of course enrollments	141,410
Average Student's Total Number of Courses	34.60
Number of departments[2]	71
Number of majors[3]	25

[1]Courses are counted by how many times they were offered. For example, the same course that was offered once in each of the twelve years is counted as 12 courses.

[2]Includes all departments that ever existed between 2001 and 2012.

[3]Excludes majors of which there were less than 30 students across the twelve years.

4.3 Measuring Breadth: Number of Unique Departments

For each student, I was interested in getting some measure of how broad their courses were across their four years at Union. To do this, I calculated the number of unique departments a student took courses in (in other words, the number of unique departments represented on a student's transcript). For example, suppose a student only took courses from the English department and the Political Science department. Then, that student would be considered having taken courses from two unique departments. This measure allowed me to compare students according to the number of unique departments they took courses in.

Since most departments are very different from one another, the number of unique departments a student took courses in is an appropriate measure of breadth. While the courses that are offered within the same department are also different in content and course material, courses from unique departments are more likely to expose a student to different perspectives, approaches, and ways of thinking. Therefore, a student who takes courses from many unique departments is likely to have been exposed to a wide range of perspectives, giving them broader knowledge. For example, if John took courses in a greater number of unique departments than Jane did, then John is considered to have taken a broader range of courses, which suggests a broader education.

Although it is a decent method, measuring breadth by the number of unique departments has its shortcomings. Some departments are more "different" from one another than some other

departments, making it difficult to distinguish the exact degree to which certain sets of departments give students a broader range of perspectives when compared with other sets of departments. Also, individual courses within the same department could differ in the degree to which they expose students to new ways of thinking, but departments do not account for this.

4.4 Accounting for Other Factors

In order to account for other factors that may contribute to changes in the number of unique departments taken by students, I looked into a few other figures. These include the number of departments that have existed throughout 2001 to 2012, the number of total courses each student took, and the number of unique departments required by major and the General Education (Gen Ed) curriculum. All of these were obtained by way of data manipulation in Stata, except for major and Gen Ed requirements, which were obtained from the Union College Academic Registers.

I thought there was a good chance that the college's number of departments had significantly changed throughout 2001-2012. If it had, I wanted to account for the change in case the number of departments affects the number of unique departments a student takes courses in. A student who attended Union at a time when there were few departments would not have the same options of courses to take as a student who attended Union at a time when there were many departments. I hypothesize that the more departments Union has, the more likely it is for students to take courses from a wide range of departments.

For similar reasons, I decided to look at the total number of courses students have taken. It might be the case that students who take more courses have a greater number of free electives and thus have more opportunity to take courses in more unique departments. To account for this possibility, I included the total number of courses in the analysis.

Furthermore, I looked at major and Gen Ed requirements. If the number of unique departments required by Gen Ed and/or major changed, then this might influence the actual number of unique departments that students took courses in. The fewer unique departments a student is required to take courses in by Gen Ed and their major, the fewer departments they are required to take overall (with the exception of their minor), thus the more likely they are to be relatively less T-shaped. In the case that the number of unique departments required by major has increased, it may be as a result of faculty and administration (the ones who make the requirements) seeing benefits of their particular majors having knowledge from other departments. Changes in Gen Ed requirements might be explained in similar ways.

4.5 Threats to Validity

There are several threats to validity of the data and methods by which the data is analyzed. First, it would have been helpful to know a student's minor (if they had one) in addition to their major. Similar to differences among students' majors, differences among students' minors could provide some explanation for the number of unique departments they took courses in. Some students do not even have a minor at all, which means they have fewer requirements to fulfill. Also, the data does not take into account students' grades, neither in individual courses nor their GPA. It also does not distinguish between students taking a course to fulfill a requirement or as a free elective. Having such information would give additional insight into students' course choices, and reasons for students taking courses in unique departments.

Additionally, cross-listed courses add some inconsistencies to the data. Due to the way the course roster pages are organized, cross-listed courses are only considered to be from one of the relevant departments. The department considered is the one in which there is a corresponding course roster page for. For example, a cross-listed course between Economics and Philosophy might be listed as "ECO-xxx-yy" in some places and "PHL-xxx-yy" in other places, but only one course roster page exists for the course, either under the URL including 'ECO' or the one including 'PHL'.

Furthermore, the way in which interdepartmental/interdisciplinary (ID) majors, double majors, and "regular" majors are grouped together poses a threat to validity. There are inherent differences between ID majors, double majors, and regular majors, one being the number of unique departments each is required to take courses in. By default, ID majors and double majors are required to take courses in at least two unique departments for their major, whereas regular majors only need to take one. The threat to validity mainly comes in when the analysis is done by major because ID majors and doubles majors are considered as being part of both major groups (whichever the majors may be). For example, an Economics/Computer Science ID major is considered to be in the Economics major group as well as the Computer Science major group. Also, double majors do not have as many free electives as regular majors do, thus changing the nature of how they go about taking courses.

Similarly, separate majors within the same department are grouped together. For example, biology majors include both regular biology majors and biochemistry majors. This may affect the analysis when broken down by major, since there are slight differences among each of the majors even though they are being considered in the same group.

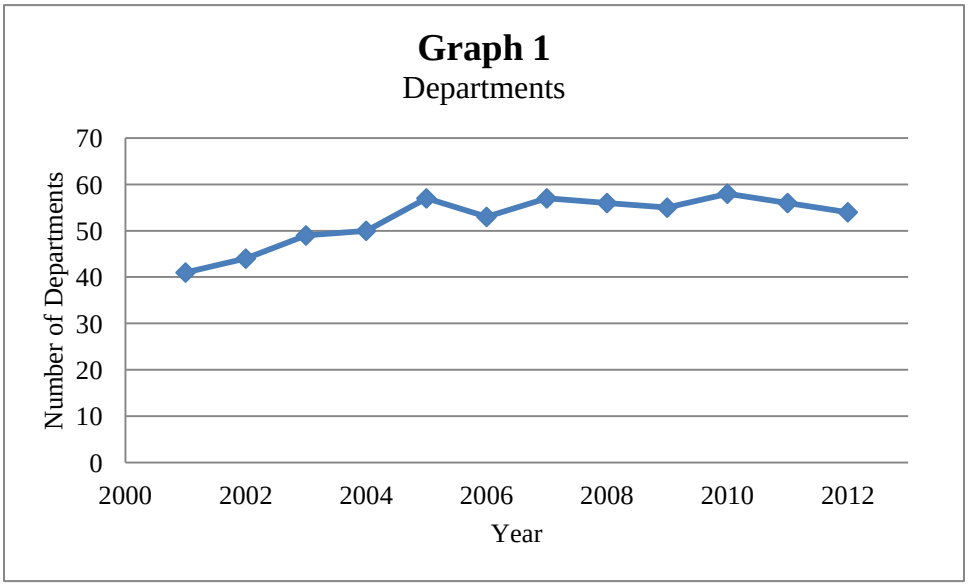
Also, some courses do not belong to a department. For example, Freshman Year Preceptorial (FYP) and Sophomore Research Seminar (SRS) are considered in the data to be their own unique departments, when in fact they are courses offered by no particular department but rather courses that each student is required to take once as part of the Gen Ed curriculum. Terms abroad (TAB) are also represented in the data as being one unique department. The individual courses that students take while on terms abroad are not accounted for in the data, thus the unique departments that students are exposed to while on terms abroad are also not accounted for.

5. Results & Discussion

5.1 Number of Departments

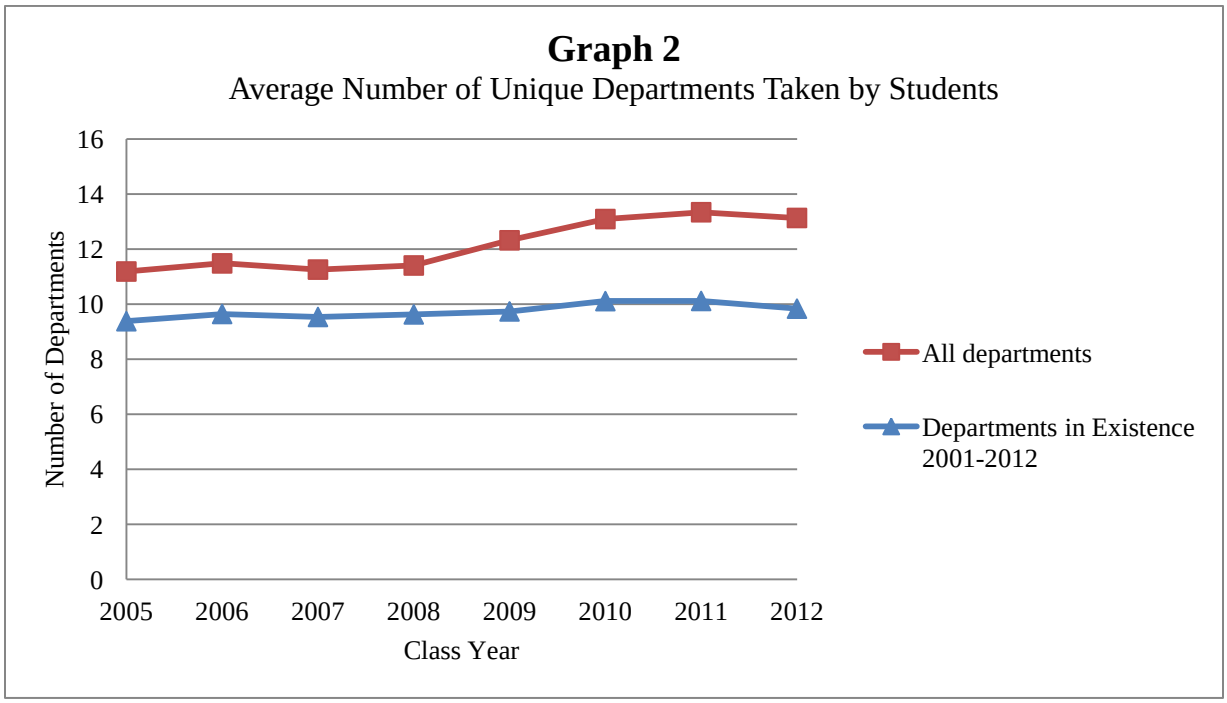
Graph 1 shows the number of departments from 2001 to 2012. As we can see from the graph, the number of departments since 2001 has increased. In 2001, there were only 41 departments but by 2012 there were 54 departments. Some examples of departments that were not offered throughout 2001-2012 include Astronomy (2005 to 2012), Film Studies (2011 to 2012), and Naval Science (2001 to 2009).

The coming and going of departments constitutes the change in the total number of departments across the twelve years. Although there were a few decreases between consecutive years (such as 2005 to 2006), there is an overall increase in the number of departments, indicating that more departments have come than gone.



Given this increase, it was important to control for the added departments. A student who graduated in 2005 did not have the same number of departments to choose from as a student who graduated in 2012 had. For this reason, the number of unique departments that students took was also calculated using only departments in existence from 2001 to 2012.

Graph 2 shows the average number of unique departments that students took courses in for each class year from 2005 to 2012. The top line shows the analysis done when using all courses that each student took, whereas the bottom line shows the analysis done when only considering courses from departments of which existed throughout 2001 to 2012.

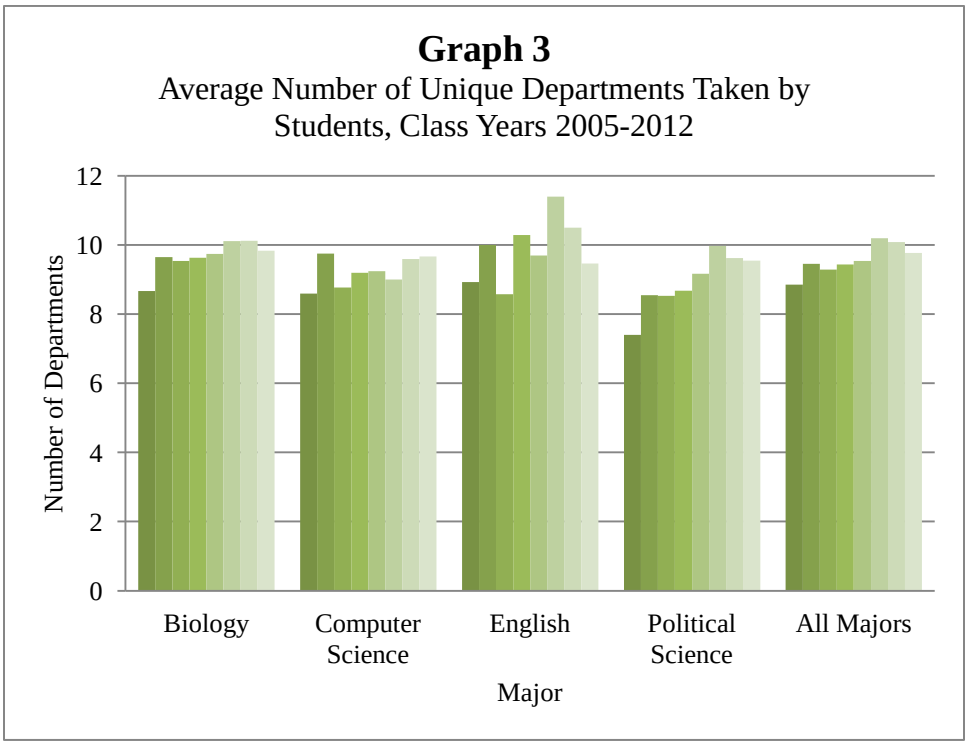


We see from Graph 2 that the average number of unique departments increased when using each of the two methods. When including courses in all departments, the average student took courses in about 11 unique departments in 2005 and about 13 in 2010-2012. These results suggest that students may have taken a wider range of courses since 2005. This is one indicator that students have been getting a broader education, thus suggesting that the average student in 2012 was more T-shaped than the average student in 2005.

When using only departments in existence throughout 2001 to 2012, the average student took courses in about 9 unique departments in 2005 and about 10 in 2010-2012. As expected, the increase is not as dramatic as it is when using all departments. This suggests that the college's

number of departments may contribute to the number of unique departments students take courses in. However, even when using only departments in existence throughout 2001-2012, there is still an increasing trend in the number of unique departments students took courses in, suggesting that there is some other reason why students have taken courses in a greater number of unique departments since 2005.

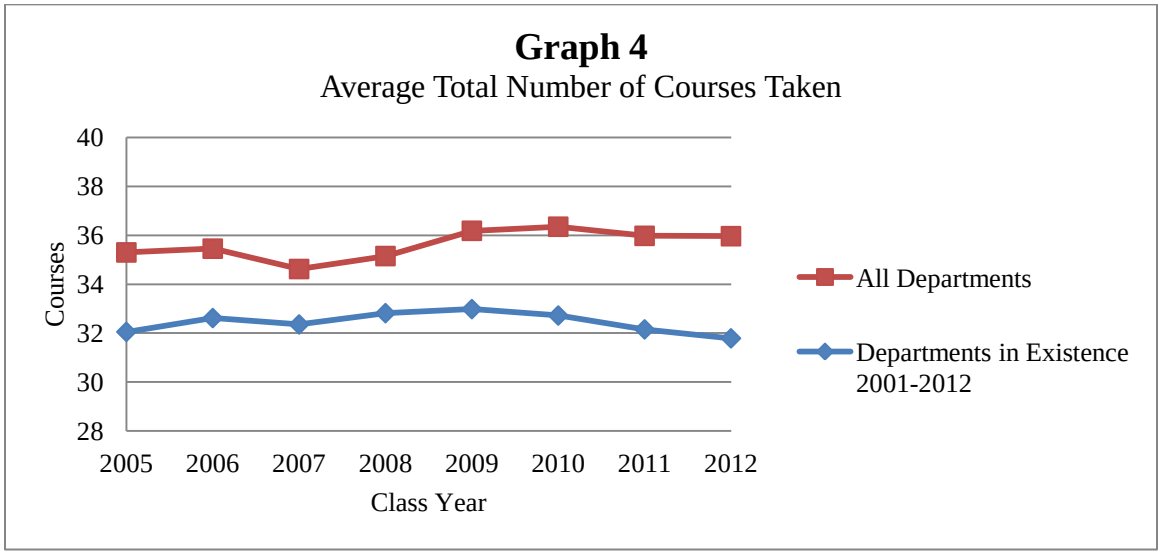
The average number of unique departments taken by students is shown broken down by major in Graph 3 (only a select few majors are shown for brevity), only including courses from departments in existence throughout 2001-2012. Although each major is slightly different, all follow the same general increasing trend.



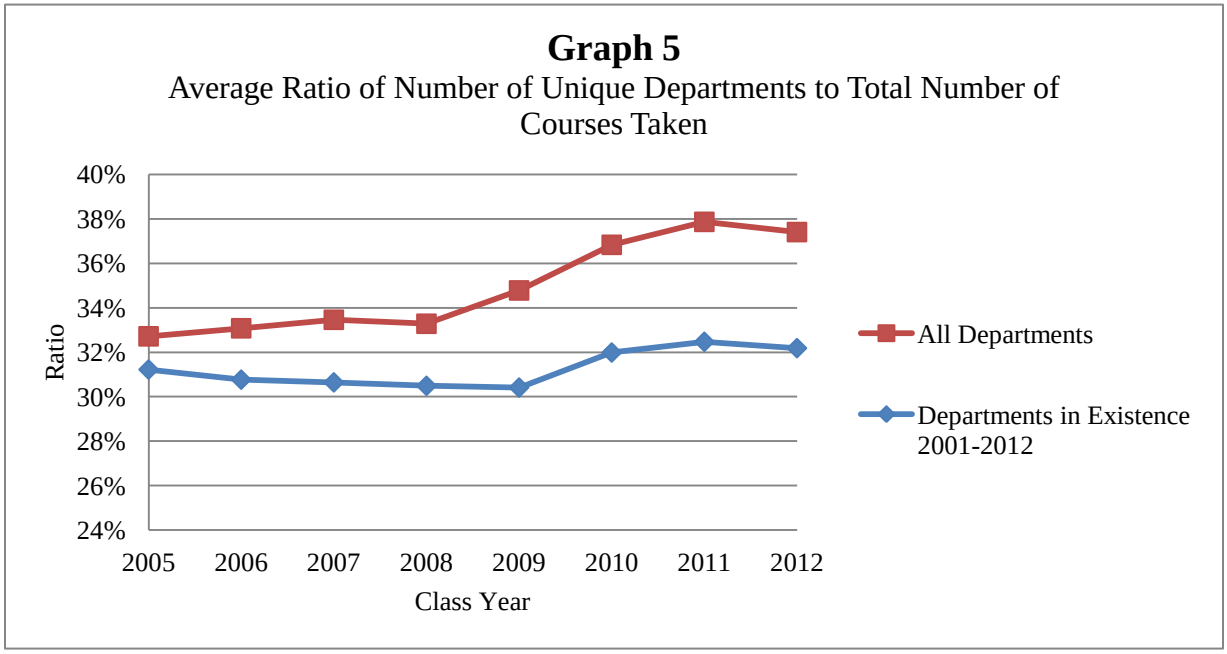
5.2 Total Number of Courses

In addition to accounting for the increase in the number of departments since 2001, I also wanted to account for changes in the total number of courses that students took. Graph 4 shows, for each class year, the average total number of courses a student completed during their time at Union. When including all departments, the total number of courses increases slightly between class years 2007 and 2009 but otherwise fluctuates only little between 35 and 37 total courses during the whole time span.

As expected, students have roughly taken the same number of total courses since 2005. There is no obvious reason why the total number of courses that students took would have changed, given the college has required the same amount of total courses for graduation since well before 2005. Interestingly, however, the increasingly wide gap between the two lines in Graph 4 tells us that students are taking fewer courses from departments that have existed throughout 2001-2012. This is probably because the newer departments are taking the place of some courses that students would otherwise take from departments that have existed throughout 2001-2012.



Although the total number of courses that students took did not increase, I was still interested in measuring the number of unique departments students took courses in relative to the total number of courses they took. In general, the more total courses a student takes, the more free electives they likely have, thus the more opportunity they have for taking courses from a greater number of unique departments. For this purpose, I calculated each student's ratio of the number of unique departments to total number of courses the student took (shown in Graph 5). For example, if Sam took a total of 36 courses in 12 unique departments, his ratio would be 33.3% (36÷12=0.333). This is some indicator of how much of their overall Union education was used to take courses in unique departments. The higher a student's ratio, the more interdisciplinary they are considered to be.



When including all departments in the analysis, the average ratio of number of unique departments to total number of courses taken stays about 33% from 2005-2008, then increases every year until it reaches almost 38% in 2011, then drops slightly to 37.5% in 2012. When only including departments in existence from 2001 to 2012, the trend is similar. The ratio decreases only slightly from about 31% to 30% between 2005 and 2009, with a jump in 2010 from about 30% to 32%.

Since the average total number of courses that students took did not change much between 2005 and 2012, it is not surprising that the ratio follows a similar trend to the number of unique departments students took as shown in Graph 2. The ratio does not change dramatically, staying around 30-32% (for only departments in existence 2001-2012). Nonetheless, there is a noticeable increase between 2009 and 2010 which may be caused by the cluster requirement being introduced (the class of 2010 was the first class required to complete a cluster): the ratio was slightly over 30% until 2010 when it rose to about 32%.

5.3 Gen Ed and Major Requirements

In addition to considering changes in the number of departments and changes in the total number of courses students have taken, I also looked at changes in the General Education requirements and major requirements. The Gen Ed curriculum "provides the foundational breadth that defines a liberal arts education through requirements in linguistic and cultural

competency, quantitative reasoning, and science and technology."[1] It has stayed similar from 2005 to 2012, with the exception of introducing a "cluster" requirement effective for the class of 2010. This requires students to take three courses in an approved cluster (e.g. "Globalization" or "Media Studies"), from at least two different departments, to "bridge and integrate information on a common topic from diverse perspectives."[2] Aside from clusters, the Gen Ed curriculum requires about 10-13 courses in roughly six departments minimum.

Table 2 shows the (minimum) number of unique required departments by major. For brevity, only four majors are shown in this table. Computer science majors, for instance, are required to take at least one math course and at least one lab science course in addition to the obviously required computer science courses, thus they are required to take courses in three unique departments. Some departments' major requirements have slightly changed throughout 2005-2012, but for the most part there has been little change: the average for all majors stayed 3.0 from academic years 2004-2005 to 2008-2009, then increasing only slightly to 3.1 in academic years 2009-2010 to 2011-2012.

Table 2

Number of Unique Departments Required by Major

Academic Year	Biology	Computer Science	English	Political Science	Average for all majors
2004-2005	4	3	1	1	3.0
2005-2006	5	3	1	1	3.0
2006-2007	5	3	1	1	3.0
2007-2008	5	3	1	1	3.0
2008-2009	5	3	1	1	3.0
2009-2010	5	3	1	1	3.1
2010-2011	6	3	1	1	3.1
2011-2012	6	3	1	1	3.1

[1] 2011/2012 Union College Academic Register, pages 33-34
[2] 2011/2012 Union College Academic Register, page 33

The results from Table 2 tell us that the number of unique departments required by major only increased very slightly, suggesting that it does not significantly contribute to the overall increase in the number of unique departments that students have taken courses in. Furthermore, this can be seen when comparing two majors with similar requirements, such as English and Political Science. English majors are not required to take any courses outside of English and Political Science majors similarly are not required to take any courses outside of Political Science (aside from the Gen Ed requirements). We see from Graph 3, however, that English majors and Political Science majors have seen somewhat different trends in the number of unique departments they have taken courses in: for some years (e.g. 2006, 2008, 2010) English majors took courses in a noticeably higher number of unique departments than Political Science majors did. Thus, major requirements do not play a big role in the overall increase in the number of unique departments students took courses in.

Although major requirements do not seem to be a factor, there is evidence that the college's number of departments is a factor in the average number of unique departments students take courses in. However, even after controlling for the college's number of departments (and the total number of courses a student took), there is still evidence that students have taken courses in a greater number of unique departments relative to their total courses, as shown by the bottom line in Graph 5. The noticeable increase between class years 2009 and 2010 could be a reflection of the cluster requirement being introduced. Although possible, there is little evidence that students are choosing on their own to take courses in a greater number of unique departments.

6. Future Work

There is much more analysis that can be done in future work. For one, it would be interesting to incorporate divisions (humanities, social sciences, natural sciences, engineering) into the analysis in addition to just departments. Knowing how many divisions a student took courses in would be an additional measure of how broad their education was. For example, consider a student who took courses in 12 unique departments from only the engineering and natural sciences divisions, but only one or two from humanities and social sciences. Despite having taken courses in a large number of unique departments, this student may not be as broad as a student who took courses in 2 unique departments from each of the four divisions (a total of only 8 unique departments).

It would also be interesting to conduct the analysis at other schools and compare the results to Union's. In particular, it would be interesting to see how the results vary based on the school's size, type, and curriculum requirements (schools with Gen Ed vs. schools with no Gen Ed). Students from a school with no Gen Ed curriculum might be less T-shaped as a result of fewer requirements, or it might be that their interests are enough reason for them to still take a wide variety of courses.

Another item for future research would be to investigate the degree to which students' being T-shaped affects their level of success after college. If there was some way to measure how successful each student became after college, then there might be a way of measuring the correlation between being T-shaped and successful. The meaning of success, of course, could be left up to the researcher's interpretation, but could include things like advances in professional life or contributions to society.

7. Conclusion

The results from this project are merely suggestive. However, future work could lead to more concrete results with important implications. With that being said, there is evidence that students are more T-shaped now than they were in the past. There is also evidence that the departments/programs offered at an educational institution plays a role in how interdisciplinary its students become. The more departments and programs available for students to choose from, the greater number of unique departments students will take courses in, thus making them presumably more T-shaped. Furthermore, curriculum requirements such as Union's cluster requirement could lead to students taking a greater number of unique departments.

An educational institution looking to make their students more T-shaped should consider creating more departments/programs and having a cluster (or similar) requirement. Assuming that doing this really would make students more T-shaped, their students would likely accumulate more human capital and thus be more successful in professional life. If many colleges and universities pursued making their students more interdisciplinary in this way, the economy might see long-term benefits.

8. Bibliography

1. Boix Mansilla, Veronica, and Elizabeth Dawes Duraisingh. "Targeted assessment of students' interdisciplinary work: An empirically grounded framework proposed." *The Journal of Higher Education* 78, no. 2 (2007): 215-237.

   This paper looks at the assessment practices of undergraduate interdisciplinary coursework. Findings are integrated into a new assessment framework. Although this paper does not relate to my research question in the way of examining full curriculum choices, it has some interesting talk about the importance of interdisciplinary studies and how to assess individual work.

2. Lattuca, Lisa R., Lois J. Voigt, and Kimberly Q. Fath. "Does interdisciplinarity promote learning? Theoretical support and researchable questions." *The Review of Higher Education* 28, no. 1 (2004): 23-48.

   This paper analyzes the efficacy of interdisciplinary curricula in comparison to disciplinary courses in the quality of student learning. The authors describe previous work in answering questions of how interdisciplinary courses affect student learning.

3. Caviglia-Harris, Jill L. "Introducing undergraduates to economics in an interdisciplinary setting." *The Journal of Economic Education* 34, no. 3 (2003): 195-203.

   This article gives evidence of the benefits of offering interdisciplinary courses in an effort to bring more students into a particular major (in this case, economics). The author provides a model based on an environmental economics course, arguing that similar courses will help attract more students to the major. The author states that the purpose of such a course is to provide substitutes, complements, or both, for principles-level economics courses because the breadth and depth of the economics content can be similar.

4. Zhao, Chun-Mei, and George D. Kuh. "Adding value: Learning communities and student engagement." *Research in Higher Education* 45, no. 2 (2004): 115-138.

This paper examines the relationship between participating in learning communities and student engagement. One interesting form of a learning community is one that is made up of students co-enrolled in two or more courses (often from different disciplines) that are linked by a common theme. In this way, the study of learning communities could have interesting comparisons to the cluster requirement at Union.

5. Hagedorn, Linda Serra, and Anne M. Kress. "Using transcripts in analyses: Directions and opportunities. New Directions for Community Colleges 2008.143 (2008): 7-17.

   This paper gives examples of how researchers could use college transcript data to understand college students' success in completing a degree. With all of the examples, however, grades are an important part of the research. A major difference between this paper and my research is that this paper uses data on grades, which I do not have.

6. Ashworth, John, and J. Lynne Evans. "Modeling student subject choice at secondary and tertiary level: A cross-section study." *The Journal of Economic Education* 32, no. 4 (2001): 311-320.

   This article sets out to explore the degree to which certain factors influence the likelihood of a student choosing to study economics. Using data from 941 British students in their final year of A-level study (at age 16; two year study prior to university), the authors look at the factors of both the likelihood of a student choosing to study A-level economics and the likelihood of a student choosing to go on to university studying economics. They find that the following affects a student's decision to study economics: mathematical ability, prior study of economics, achievement in economics, and certain features of the classroom environment (including gender combinations of teacher and student, ability of fellow economics students, and interest in economics).

7. Berger, Mark C. "Predicted future earnings and choice of college major." *Industrial and Labor Relations Review* (1988): 418-429.

   This article concludes that when choosing a college major, students are more likely to choose one major over another if the predicted future earnings stream of that major is

relatively greater. The study finds that students do not care about the beginning earnings of a major and instead consider earnings streams when making education investments.

8. Fournier, Gary M., and Tim R. Sass. "Take my course, please: The effects of the principles experience on student curriculum choice." *The Journal of Economic Education* 31, no. 4 (2000): 323-339.

   This paper aims to identify the degree to which different elements of the economics principles (introductory/core) courses affect a student's decision to take additional economics courses. After analyzing data on students at Florida State University from 1991 to 1993, the authors make some interesting conclusions pertaining to the effects of class size, faculty grading, and faculty quality on the likelihood of a student taking additional courses. The authors state that their research could be extended if a study were done at a small liberal arts institution or a large university.

9. Malgwi, Charles A., Martha A. Howe, and Priscilla A. Burnaby. "Influences on students' choice of college major." *the Journal of Education for Business* 80, no. 5 (2005): 275-282.

   This article presents a study that uses survey data from students at one particular business school to examine influences of students' choice of major. They find that interest in the subject is the primary influence, while high school experience is not a factor. They also find interesting gender differences: women are more influenced by their aptitude in the subject than men are, and men are more influenced by the expected future earnings than women are. Furthermore, change in major is influenced most by interest in the subject and career opportunities. The authors suggest further research using students at a liberal arts college.

10. Montmarquette, Claude, Kathy Cannings, and Sophie Mahseredjian. "How do young people choose college majors?" *Economics of Education Review* 21, no. 6 (2002): 543-556.

    This article builds on former articles related to how students choose their college majors based on expected earnings. Unique from previous studies, the authors distinguish three parts to expected earnings: perceived probability of success, expected earnings after

graduation and the earnings alternative if the student fails to complete a college program. The results show that the choice of college concentration depends on expected earnings.

11. Porter, Stephen R., and Paul D. Umbach. "College major choice: An analysis of person–environment fit." *Research in Higher Education* 47, no. 4 (2006): 429-449.

    This article sets out to identify factors that determine a student's choice of major. The study finds that political views and personality traits are especially indicative of a student's major choice. Furthermore, they find that academic preparation, family influence, academic self-efficacy, and gender are not significant factors after controlling for personality. Personality traits were based on four of Holland's model environments: investigative, social, artistic, enterprising.

12. Ham, Roger, Pramod N. Junankar, and Robert Wells. *Occupational choice: personality matters*. No. 4105. IZA discussion papers, 2009.

    This article examines the effect of an individual's personality traits and status of their parents on the likelihood of them having a white collar occupation as opposed to a blue collar occupation. This paper is included in the annotated bibliography because occupational choice is similar to curriculum/major choice.

13. Miller, Robert A. "Job matching and occupational choice." *The Journal of Political Economy* (1984): 1086-1120.

    This paper discusses how people go about choosing occupations and changing jobs throughout their career. The longer a person stays in one particular occupation, the more specific their skills become and the less likely they are to be marketable in other fields and therefore are more likely to stay in that occupation. On the contrary, people who move around in their career are more marketable. This paper rejects the hypothesis that people do not switch occupations. They find the jobs yielding returns that are subject to uncertainty are experimented with first in a person's career path. Although this article is about occupational choice, it relates to my research in the sense that it is similar to curriculum choice in some respects: choosing jobs and career paths can be paralleled to choosing courses and curriculum paths.

14. Johnson, Eric J., Suzanne B. Shu, Benedict GC Dellaert, Craig Fox, Daniel G. Goldstein, Gerald Häubl, Richard P. Larrick et al. "Beyond nudges: Tools of a choice architecture." *Marketing Letters* (2012): 1-18.

    This article talks about various tools that can aid a choice architect (anyone who presents people with choices) in structuring a choice task and describing choice options. This relates to the study of college curriculum programs and requirements because they are aspects of the choice environment faced by student consumers as shaped by the program choice architects.

15. Scott-Clayton, Judith E. "The shapeless river: does a lack of structure inhibit students' progress at community colleges?" (2011).

    This article examines the role of program structure in student persistence. It explains that community college students are better able to navigate through a curriculum successfully when there are tightly structured programs that give students little room to deviate from paths toward degree completion. Although I am not researching student persistence, this paper relates to my research because it talks about the ways in which students navigate through a curriculum when there are different sets of choices available to them, such as (in my case) interdisciplinary programs.

16. Thaler, Richard H., and Cass R. Sunstein. *Nudge: Improving decisions about health, wealth, and happiness*. Yale University Press, 2008.

    This book talks about how decision making is influenced by the choice environment. The authors show how choice architecture can be used to help nudge people to make better choices without forcing any outcomes (also called libertarian paternalism). This relates to my research on curriculum choice because the college's available programs are a form of choice environment, and the students are the decision makers.

17. Leonard, Dorothy, and Sylvia Sensiper. "The role of tacit knowledge in group innovation." *California management review* 40, no. 3 (1998).

This article evaluates the skills and processes necessary for group innovation. It relates to the motivation for my research in the way the authors argue the importance of various perspectives and viewpoints in learning and working environments.

18. Donofrio, Nicholas, Calline Sanchez, and Jim Spohrer. "Collaborative Innovation and Service Systems." *Holistic Engineering Education: Beyond Technology* (2009): 243.

    This particular chapter shows that companies like IBM value people with both specific (deep) and integrative (broad) skills (I-shaped vs. T-shaped) individuals, giving motivation to my research.

19. Beraud, André. "A European research on women and Engineering Education (2001-2002)." *European journal of engineering education* 28, no. 4 (2003): 435-451.

    This article gives evidence that women and underrepresented groups are more attracted to studying interdisciplinary and socially relevant subjects than are other groups. Thus, it helps make the case for the importance of interdisciplinarity.