Interdepartmental Requirements

Mark McClure

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A quantitative look at the interdepartmental dependencies between academic departments at UNCA in 2024/25

Introduction

This report explores the outside dependencies of academic departments at UNCA on courses from other departments. The intention is to illustrate the influence and importance of some departments by investigating how their courses are required by other departments.

Not surprisingly, the fundamental sciences of mathematics, physics, and chemistry feature prominently in this analysis. To be clear, though, it is *not* the intention of this report to denigrate the value any department due to its ranking here. Our department of Engineering, for example, features no courses that are required by other departments yet no "Future Forward" analysis of engineering's role in the modern curriculum can escape its intrinsic value. It's also the opinion of this author that intrinsic value of the whole division of Humanities is self-evident; that's another issue, though.

Nonetheless, with recent cutbacks and the possibility of more, it seems reasonable to explore the potential impact of any such cuts on the overall curriculum. Thus, every department carries not just it's own intrinsic worth but, also, it's value within that interdepartmental structure.

Main illustration

There are 16 degree granting programs at UNCA that either require some of their majors to take courses from outside their department or offer at least one course that's required by another department. The easiest way to visualize these relationships is with a network diagram. In Figure 1 below, a directed edge from one Dept A to another Dept B indicates that Dept A offers at least one course that's required by Dept B; the thickness of each edge is proportional to the number of courses.

Note the confluence of arrows in and out of the Math node suggesting its centrality in the curriculum. Physics and Chemistry both appear quite central as well, though the edges aren't quite as thick or numerous as they are for Mathematics. We should try to be more quantitative to distinguish these more completely.

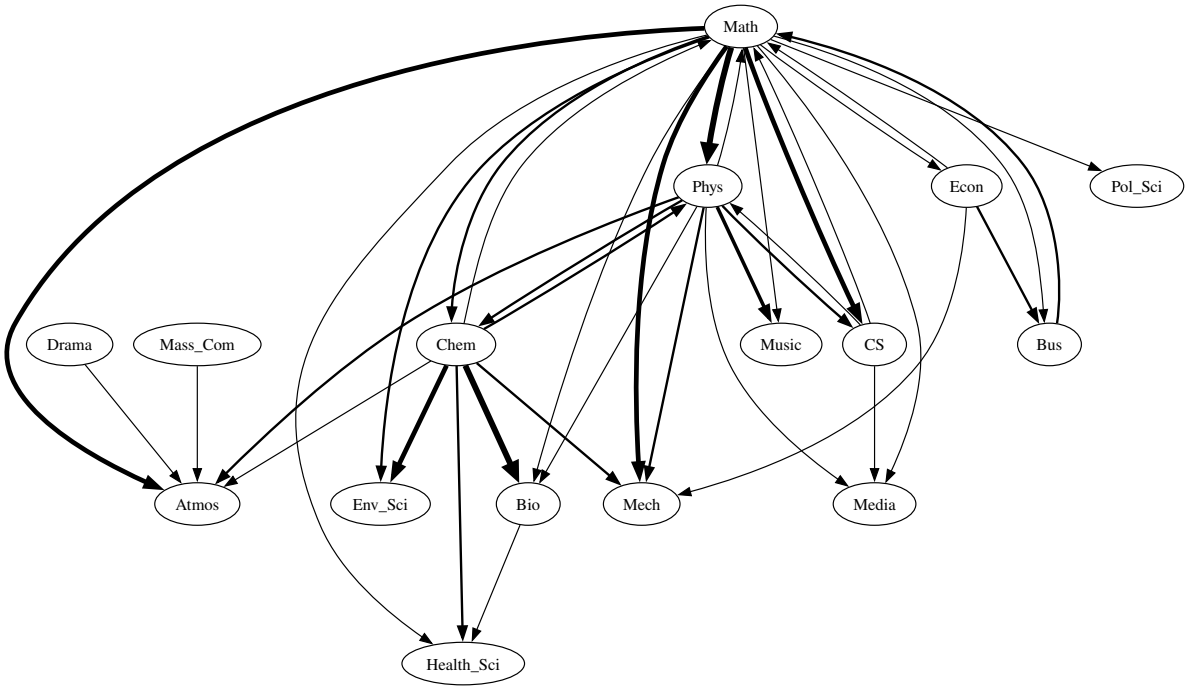

Figure 1: Interdepartmental dependency network diagram

Quantifying the diagram

Figure 1 is built on real data taken from our course catalog as described in detail in the final section on data. In this section, we describe how to use those numbers to quantify departmental influence more precisely.

Simple degrees

The easiest way to quantify the influence of the nodes in the diagram is to simply count the outward bound edges for each node. When doing so, it's also important to account for the number of courses corresponding to each edge; that number is reflected in the thickness of an edge and those numbers are clearly indicated in the data, as described shortly. Note that the outward bound edges correspond to the dependents for each department and the inward bound edges correspond to requirements. In network theory, these numbers are called the *in and out degrees* of the node. The departments in the graph are listed in Table 1, which is sorted in descending order by out-degree.

Table 1: Departments by vertex degree

Department	Abbreviation	Requirements	Dependents
Mathematics and Statistics	Math	6	28
Chemistry and Biochemistry	Chem	4	17
Physics and Astronomy	Phys	8	14
Economics	Econ	1	4
Computer Science	CS	6	3
Business	Bus	3	2
Biology	Bio	7	1
Drama	Drama	0	1
Mass Communication	Mass Com	0	1
Atmospheric Sciences	Atmos Sci	9	0
Engineering	Mech	9	0
Environmental Science	Env Sci	6	0
Health Sciences	Health Sci	4	0
Music	Music	4	0
New Media	Media	3	0
Political Science	Pol Sci	1	0

Note that the department of Mathematics has by far the largest number of dependents. Physics and Chemistry are next closest with around half the number of dependents and still far past the rest.

Input-output rankings

While the out-degree is simple and compelling, there are also standard tools for measuring the influence of a node in a network like this that accounts for flow through the entire network. One such model, developed to measure the flow of goods between industries in economics, is sometimes called an *input-output model*. We can use an input-output model to easily produce finer ratings; the result is shown in Table 2.

Table 2: Departments by input-output rating

Department	Input-output rating
Mathematics and Statistics	1
Economics	0.39
Physics and Astronomy	0.37
Business	0.33
Chemistry and Biochemistry	0.26
Computer Science	0.21
Biology	0
Drama	0
Mass Communication	0
Atomospheric Science	0
Engineering	0
Environmental Science	0
Health Sciences	0
Music	0
New Media	0
Political Science	0

Note that each rating is simply a number between zero and one; the larger the number, the more influence the department has in the network. We again see that Mathematics has by far the strongest influence. The departments of Economics and of Business are rated so high largely because Mathematics has requirements in those programs through its concentration in Statistics.

Mathematical details The input-output ratings are computed using exactly this description from Wikipedia. This technique assumes there is a vector $\mathbf{x}$ representing the output of each department and a vector $\mathbf{y}$ representing the final demand for each department. The vector $\mathbf{x}$ is the unknown that we are looking for. The vector $\mathbf{y}$ is chosen to be the constant vector $\mathbf{1}$, which simply assumes that all departments have equal intrinsic value. These vectors are related via the formula

$$\mathbf{x} = A\mathbf{x} + \mathbf{y},$$

where A is the transition matrix described by the network structure. The input-output ratings are computed by solving that system.

Data

The data for this report comes exclusively from UNCA's course catalog. If you navigate specifically to the list of academic programs and their requirements, you'll find a list of those programs with pointers to their specific concentrations. The hyperlinks to those concentrations list any required courses outside the major that the concentration might have. This report uses those lists to determine an overall dependency structure.

What's included

Not all programs play a role in the dependency network. First off, this report considers *only undergraduate degree granting departments*. That excludes programs on the list of academic programs like Honors, Other Programs, Special Study Programs, and Study Abroad, as well as the MPH. It also notably excludes the Department of Education, which is not degree granting.

This report also excludes Interdisciplinary Studies, which (while degree granting) consists largely of courses from other departments. These are all *core* courses; Interdisciplinary Studies lists no outside requirements.

Finally, there are 10 degree granting programs that neither have outside requirements for their majors nor provide any outside requirements for other majors. Those departments are: Ancient Mediterranean Studies, Art and Art History, English, History, Languages and Literatures, Philosophy, Psychology, Religious Studies, Sociology and Anthropology, and Women, Gender and Sexuality Studies.

Determining the relationships

Most departments offer more than one concentration and each concentration has its own set of outside requirements. In many cases, these outside requirements are consistent with one another. In other cases, it can be more complicated to determine a set of outside requirements consistently with other departments.

The Department of Business, for example, contains two concentrations - Accounting and Business. Both of those concentrations have the same outside requirements: ECON 103 and ECON 306 from the Department of Economics and STAT 185 or STAT 225 from the Department of Mathematics and Statistics. We would say that the Department of Business has *three outside requirements*. We would also say the Department of Economics has *two dependents* (i.e. courses on which other courses depend) and that the Department of Mathematics and Statistics has one.

My own department of Mathematics and Statistics lies at the other end of the complication spectrum with a complicated string of "ands" and "ors" and other possibilities that's difficult to deal with consistently. We have three concentrations (Pure Math, Applied Math, and Stats) all of which require outside

sequences that can be chosen from multiple departments. In these kinds of cases, I chose the dependency structure to be represented as widely as possible while trying not to overinflate the number of edges. As an example, suppose that a department has requirements

- Physics 221 and 222, *or*
- Chemistry 231 and 232, *or*
- Business 225 and Economics 103.

That leads to four arrows from each of those departments to mathematics. Of course, some students will take physics and some will take chemistry so it seems fair to split those. Business and economics both get an arrow, since there's a requirement from each department.

Conclusion

All departments at UNCA (past and current) have immeasurable intrinsic value. The fundamental sciences play a special role via their contribution across the curriculum. Even within that distinguished group, Mathematics and Statistics plays a dominant role.

One final point worth mentioning is that the Mathematics courses that are required by other majors are not just introductory classes but, also, 200 level classes like Multivariable Calculus, Discrete Mathematics, and Math for Machine Learning, as well as 300 level classes like Differential Equations.