OIRAE Briefing
April 2016

PURDUE UNIVERSITY

Curricular Efficiency for Degree Completion

Degree attainment is the primary goal for most students enrolled at Purdue. Many analyses have studied the best pathways for attainment of a Purdue degree[1]. This briefing introduces a new analysis based on degree requirements, focusing on the complexity of the curriculum structure and the potential impact on a student's ability to complete the degree requirements or contemplate switching to another major.

The motivation for this study of Purdue's curricula structures comes from a study done at the University of New Mexico[2]. Curricula Analysis System (CAS), constructs and visualizes degree curricula using a diverse set of data sources such as Degree Works, Banner, and Student Academic Record. The modularized design allows the system to be easily expendable to incorporate future data sources. The system uses Directed Acyclic Graphs (DAG) to visually represent the curricular structure via logical structure nodes and leaf (course) nodes. It also attaches pre-requisites and co-requisites to courses in a degree's requirements.

CAS Basics

CAS integrates with several data sources that describe course and degree requirements. Degree course requirements are stored in Degree Works and are represented in the SCRIBE programming language. The official rules and requirements that a student must meet to complete a degree are stored in 'blocks' of SCRIBE code.

CAS parses each SCRIBE source file to produce a DAG as shown in Figure 1. Red circles represent actual courses; light blue circles represent 'and/or' logical relationships; gray circles (k of n) means that a student needs to satisfy one or more branches to fulfill the requirements; arrows represent dependencies of the requirements; and yellow boxes represent sets of requirements . The yellow boxes in Figure 1, for example represent NRS-GENED (Core Req Nursing), NRS-GEN-REQ (General Required Courses), etc. Nursing requirements have been defined in these types of blocks of requirements. This type of visual representation can help identify complexities in degree requirements.

Figure 1: Graph representation of degree requirements for Nursing

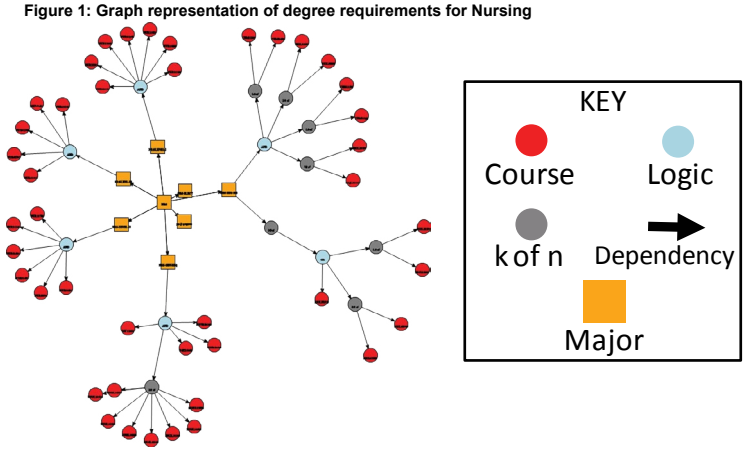
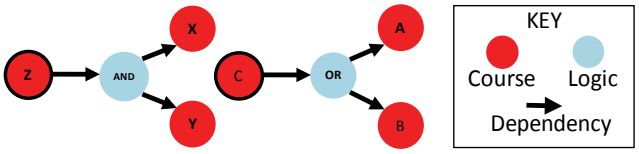


Figure 2a (left) 2b (right): Graph representation of pre/co-requisite dependencies



Furthermore, CAS parses pre and co-requisites that specify the order that the students must take the courses as shown in Figure 2. For example, Figure 2a shows that to take course Z, a student must have completed both courses X and Y. And Figure 2b shows that to take course C, a student must have completed either course A or course B. Using this information CAS can identify long chains of dependencies or bottleneck courses that have many pre/co-requisites.

Pilot Uses

The initial testing and validation of CAS was done on majors from the College of Health and Human Science (HHS). The following four use cases discuss some of the practical applications of the system to assist students and Purdue faculty and staff.

Major-to-Major Similarity

One use case for CAS is the ability to easily compare degree requirement structures using a similarity index. This can help academic departments design majors within the college by determining similarities between newly proposed majors and existing majors.

The similarity index measures the similarity between majors in a directional manner ranging from 0.0 (not similar) to 1.0 (completely similar). The similarity index is not bi-directional, meaning just because Major1 is similar to Major2 doesn't mean that Major2 is similar to Major1. The index measures the overlap of one major's course requirements and the logical structures of the pre-requisite and co-requisites as it overlaps with another major.

Figure 3 represents analysis results for two majors in HHS. In figure 3a, Medical Laboratory Science (MLAB) major in HHS is compared to all other majors also in HHS. MLAB was selected in this case study because its curriculum overlaps with a few majors within HHS. The x-axis similarity index represents the magnitude of overlapping courses and logical structure of MLAB to other majors in HHS. The major in Occupational Health Science (OCCH) shown in the top right quadrant has a similarity index of 0.55 on the x-axis which can be translated to read that MLAB's degree requirement are 55% similar to OCCH. Conversely, the y-axis similarity index represents the magnitude of overlapping courses and logical structures of a major in HHS to MLAB. Reading the similarity index on the y-axis on figure 4a, OCCH is 0.74 similar to MLAB. The course requirements and the logical structure overlap for these two specific majors. Some courses which overlap are Health Sciences 101 & 202, General Physics I & II, Chemistry (CHEM 1 & 2), Human Anatomy and Physiology, and English selectives such as ENGL 306 (Professional Writing), ENGL 420 (Business Writing), ENGL 421 (Technical Writing) to name a few.

On the other hand, the Nursing (NRS) major in HHS does not overlap with other majors in HHS, as shown in Figure 3b. The similarity index to other majors in HHS generally fall below 30%. The Accelerated Nursing major (NRSA) is an advanced nursing curriculum which shows up as highly similar to NRS, since it is considered as a 'second degree' accelerated baccalaureate program in Nursing.

Figure 3a. Major-to-Major similarity for MLAB

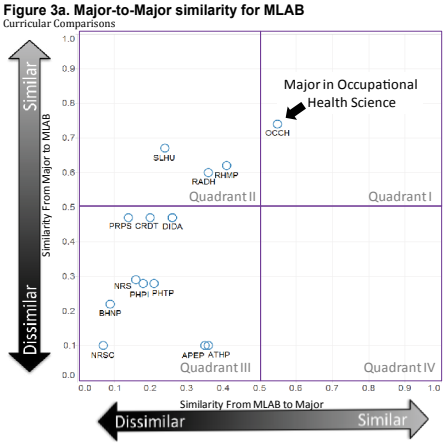
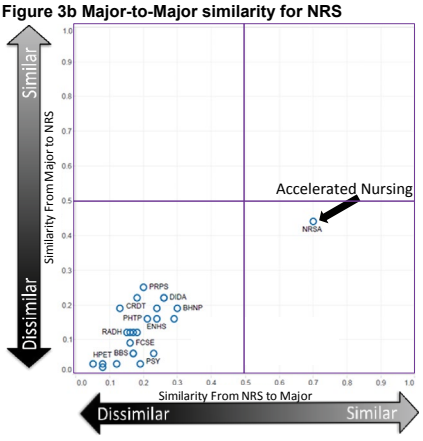


Figure 3b Major-to-Major similarity for NRS



Curricular Efficiency for Degree Completion

A Student's Nearest Major

Students who are considering choosing a different major can face a big challenge navigating complex degree requirement structures. Many curricula at Purdue can be complicated due to conflicting and additive requirements coming from state mandated accreditation, university, or departmental requirements. Additionally, free elective courses, pre/co-requisites that can be satisfied in multiple ways also contribute to the complexity of the degree curricula.

Combined with the student course history, CAS can calculate a given student's nearest majors or alternatively distant majors also. This allows a student or advisor to view majors which most closely match the set of courses that the student has already completed. This nearest major metric provides a tool to guide a student's choice to switch majors and the impact on his/her time to graduation. The nearest major metric also can provide a mechanism for students to explore possible additional majors.

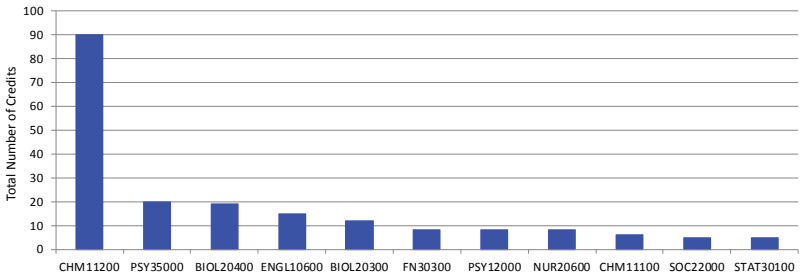
The Nearest Major Metric (NMM) is calculated by stepping through the major's degree requirements expressed as a DAG and flagging the course nodes which the student has successfully completed. The ratio of the credit hours completed to the minimum number of credit hours left to complete the degree is represented by NMM. In Figure 4, the NMM is shown for an example student who has completed his first year majoring in Medical Laboratory Sciences and switched to first year engineering then switched to Chemical Engineering. Given the student's completed course history, the metric indicates that the Chemistry Education major's course requirements are already 35% satisfied. Several other nearest majors have a fair amount of coursework satisfied. Another interesting finding is that the Aviation Management major appears to be a relatively near major given the student's completed course history. This type of information can help students and advisors as they weigh the impact of switching majors.

Figure 4. Top 10 nearest majors to the given student's current major of Chemical Engineering

Similar ↓ Dissimilar

NMM	Major	Description
0.35	CHED	Chemistry Education
0.32	CHEM	Chemistry
0.27	CHBI	Bioinformatics Chemistry
0.25	PHAR	Pharmaceutical Sciences
0.25	CHMA	Chemistry- American Chemical Society
0.25	BICH	Biochemistry (Chemistry)
0.23	ESSE	Earth Space Science Education
0.22	AVMG	Aviation Management
0.20	ENHS	Environmental Health Sciences
0.20	RADH	Radiological Health Sciences

Figure 5. Courses blocking the most total number of credits for HHS majors



Critical Courses

There are many definitions of critical courses. In this study, we utilized CAS to examine those courses that if a student does not successfully complete will block his/her path onto other required courses for the degree requirement. In other words, those courses which are prerequisites to many other courses required for the major.

Figure 5 shows an example of courses required for the Nursing major. CHM11200 (General Chemistry) is required in order to move forward in the Nursing major; it blocks the pathway to 90 credit hours of other courses.

As a validation of the results from CAS, the study examined a list of critical courses to determine correlation with on-time graduation. The graduation rate is 89% among students who take CHM11200 in their first term and earned an A or B grade. The graduation rate is 38% among students who take CHM11200 in their third term and earned an A or B grade.

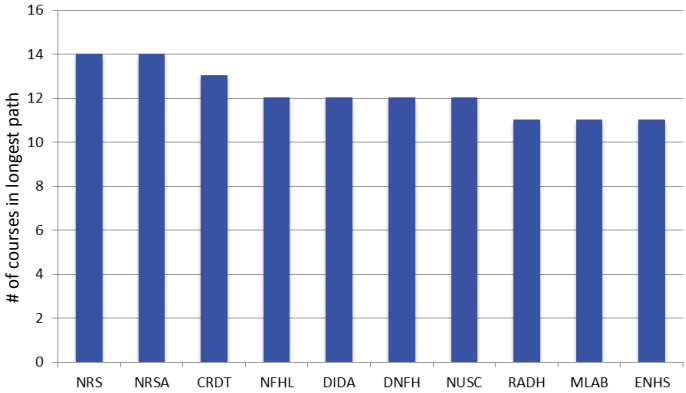
Longest Path

CAS can identify a set of courses within the major that could be potential bottlenecks for a student. A sequential series of courses could be challenging to complete within four years if a student fails one of the courses in the series or does not start to take the courses early enough to complete the series on time.

Figure 6 shows the top 10 majors in HHS sorted by the number of courses in the chain of prerequisites. The longest path is in the Nursing major with 14 courses, which includes courses that are required for the degree and prerequisites. For Nursing, this includes prerequisite courses such as pre-calculus, which a student may have completed before starting the major.

Future development of CAS will include merging the student course history with the longest path analysis to identify longest paths relative to a particular student.

Figure 6. Top 10 longest series of prerequisites for majors in HHS



Conclusion

Preliminary CAS output has been examined by domain experts in the college of HHS as well as in the Office of the Registrar. The metrics discussed in this briefing may serve as a basis for a tool provided to assist faculty and administrators in creating curricula as well as a tool to help students navigate the possibility of switching majors in a timely manner for minimal impact on time to graduation.

Some future development ideas for CAS are as follows:

- Expand into case studies for other colleges (contact oirae@purdue.edu)
- Explore new metric to guide course scheduling and expected enrollment
- Based on varying criteria, select a set of critical courses
- Combine relevant metrics with student's academic record

[1]http://www.purdue.edu/oir/OIRAEBriefings.html

[2]Wigdahl, J., & Heileman, G. L., & Slim, A., & Abdallah, C. T. (2014, June), Curricular Efficiency: What Role Does It Play in Student Success? Paper presented at 2014 ASEE Annual Conference, Indianapolis, Indiana. https://peer.asee.org/curricular-efficiency-what-role-does-it-play-in-student-success

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