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COSMIC: US-based Conversion Master's Degree in Computing

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MARQUETTE UNIVERSITY

BE THE DIFFERENCE.

Introduction

Since its inception in 2000, Marquette University's MS in Computing program has offered a career change opportunity for individuals with little formal computing education (referred to as a "conversion course" in the UK). Like most US-based graduate programs, our Computing program required several Computer Science (CS) pre-requisite courses. These pre-requisites typically meant students were delayed at least a year before beginning in-depth computing study.

This poster discusses our National Science Foundation (NSF) S-STEM supported conversion initiative entitled COSMIC, Change Opportunity – Start Masters In Computing. COSMIC begins with a summer bridge course immediately followed by a cohort term that provides students with a rapid transition into our MS in Computing program.

Overview -- Summer Bridge Course

An 11 week / 5 days a week / 8 hours a day intensive face-to-face summer bridge course employing traditional lecture, active-learning lab work, student presentations, independent study and team-based work that intermix foundational topics with the study of software development and common computing architectures. Topics include:

Programming

Algorithmic thinking and computer-based problem solving is developed via an application-focused excursion through Python packages. Student exercises include integrating a program with the underlying operating system (OS), using a simple GUI toolkit, accessing content on the web, and accessing databases. Access to OS resources introduces APIs, buffering and other concepts.

GUI interfaces are employed to introduce concepts such as cooperating processes and interprocess communication. The section on the web introduces HTML, formal language description (as used in computer languages), web architecture and the exchange of information between browsers and applications.

The database excursion introduces ideas regarding data organization (schema), modeling, and the predominant long-term storage mechanisms used by enterprises.

Professional Practice

After they are introduced to programming, students conduct professional programming practice self-study, including debugging, testing, and project coordination. To encourage soft skills required for life-long learning and expressing technical concepts to others, students make presentations on the topics they studied.

SQL

Within the application-focused view of Python programming, there are exercises using SQL to create and query databases. Students undertake SQL self-study in preparation for the end of term team project. With the continuous evolution of technology, it is important that students develop the habits and skills to absorb documentation to learn new technologies. To further foster communication skills, students give a presentation on their SQL self-study.

OS Commands and Scripting

The SANS Institute provides free, online open course format tutorials *SANS Cyber Aces Online* (Cyber Aces). Tutorials include introduction to the file system and user access control mechanisms for Windows and Linux, the Open System Interconnect model (OSI model) and scripting with PHP, Bash and PowerShell.

Data Structures and Algorithms

Algorithm analysis and computational complexity in the context of considering data structures, abstract data types, object-oriented design, algorithms and alternative implementations.

Team Project

Using Python, students build an object-oriented representation of a Black Jack game. They implement a players and playing records database and employ a user interface toolkit (Flask) to support interaction with the player. Students are encouraged to divide up the work and interact with one another to build an integrated solution. A distributed architecture is introduced involving the typical web-based application consisting of a browser-based user interface, web server, application server and a database component. In the database portion of the Black Jack project, students move from using SQLite locally to accessing MySQL on a remote server. The user interface toolkit is introduced through a tutorial that includes ideas of application testing and packaging of applications for broader use. The eventual goal is to host the application on a virtual machine server. The project emphasizes APIs, simple web architectures, abstractions, project management and teamwork. A final presentation discussing design choices, challenges and a Black Jack game live demonstration concludes this section of the bridge course. Students gain experience in preparing demonstrations and learn that it is common to encounter problems during a live client presentation.

Computing Culture

Our past bridge courses have met daily for full 8-hour days, there are opportunities to question and discuss ideas that are part of the culture of computing, as seen from the inside of the business. While students have end-user experience with computers, cellphones, laptops and other computing services and systems before they arrive, the summer course exposes them to some of the practices of building these services; students experience the rough edges of computing technology that professionals are asked to master. For example, installing a piece of software in Windows or adding a cell phone app is often effortless, but installing and using a package in Python requires a very different level of understanding.

MS in Computing Program & COSMIC

Our MS in Computing program is a professional terminal degree program with learning outcomes:

- O1: Appraise relationships among a variety of computing practices and technologies to create integrated solutions to computing problems.
- O2: Communicate computing problems and suggested solutions to other professionals and with business clients.
- O3: Formulate and defend realistic and detailed designs for solutions of problems of enterprise scope.
- O4: Evaluate and apply common standards for technology and technology management.

These learning outcomes are typically measured through practicum experiences.

The MS in Computing Academic Program

The MS in Computing program requires students to have a primary career focus (*i.e.*, at least 12 credit hours related to their primary career focus), a secondary career focus (least six credit hours in a secondary area), an overall credit total and a minimum GPA requirement.

The MS in Computing program offers a coursework only option (36 credits), a thesis option (30 credits) and COSMIC (42 credits). Students not doing a thesis may do a practicum or professional project to add experience to their academic plan. COSMIC students are strongly encouraged to explore internships (a practicum) to add work experience in the computing field to their resume.

The MS in Computing program relies on > 25 courses taught annually in the Department of Computer Science (COCS); these courses are taught by either research faculty or experienced professionals serving as adjuncts. True to the interdisciplinary aspect of computing, graduate courses taught in other departments, such as computer engineering and information technology, are applicable. Breadth of computing study in encouraged both within the department and across the campus. Courses in COSC range from those that are technical such as Networks and Internets to those that are application-oriented such as an Introduction to Information Systems.

Another aspect of the MS in Computing program is offering distance learning for most COSC courses typically taken by students in the MS in Computing program. In many courses, synchronous distance learning is facilitated by adding cameras and speakers into classrooms and using web-conferencing software to connect remote students. Several courses are asynchronous offerings.

COSMIC Coursework & Strengthening Cohort Formation

Immediately following the bridge course, COSMIC students as a cohort are advised to enroll in:

- Elements of Software Development (3 credits)
- Principles of Database Systems (3 credits)
- Professional Seminar in Computing (1 credit)

Elements of Software Development employs a project-oriented approach to explore software design and development process. This course reinforces and builds upon the bridge course Professional Practice and Team Project elements. Experience and knowledge derived from this software development course are essential for computing professionals.

Principles of Databases Systems is a standard elective course. For COSMIC students, it provides an essential common understanding of databases that is shared with those who have studied computing at the undergraduate level. This database course includes a project exercising application interfaces to databases and interaction with data stores. The SQL components of the bridge course are designed to prepare students for their new career and *this database course*.

The Professional Seminar in Computing is an asynchronous online class that students can take each academic term. Each offering of the seminar is built around a topic of professional interest, and the topic varies each term. The seminar is designed to give students experience researching topics of interest to computing professionals. Students are asked to synthesize information from academia, industry experts, vendors, and analysts to develop and express opinions on technology trends. The seminar is to equip students with an approach to life-long learning that is essential to success in a career with ever-evolving technology.

By encouraging COSMIC students as a cohort to enroll in these three courses, any natural bonding that emerges from the bridge course is reinforced. COSMIC students are encouraged to work together, share difficulties, and help one another through the transition into computing.

Data

Cohort numbers are small. While partially due to S-STEM scholarship limitations, the greatest limitation has been the full-time 9-5 nature of the bridge course which, in summer 2020, has us pursuing an online model. In our summer cohorts, 15 of 17 members were low-income students eventually deemed eligible for NSF S-STEM scholarships.

Undergraduate Degrees: accounting (2), administration of justice/law enforcement (2), biochemistry (1), business administration (1), criminology (2), English (1), geography (1), information science and technology (1), liberal arts/philosophy (2), math and Spanish education (1), psychology (2), sociology (1). Throughout, parentheses indicate the number of reporting students, e.g., two students had undergraduate degrees in criminology.

Gender: male (11), female (6); ***Ethnicity:*** Hispanic or Latino (3), not Hispanic or Latino (13), one did not provide a response; ***Race:*** American Indian or Alaska Native (2), Asian (3), Black or African American (6), White (9); totals more than seventeen since three individuals reported biracial. ***Previous Computing (non-user) Experience:*** No previous computing experience (2); some self-study (14); related coursework (6); certification (2); worked in field (4, Help Desk)

Anticipated Hours of Employment During Full-Time Study: Forty or more hours per week (4); Twenty or more hours per week (5); Ten hours per week (3); Zero hours per week (5)

Instructor Survey: In May 2019, we surveyed consenting instructors who taught one or more conversion students in spring. There were 21 enrollments by 8 conversion students in nine courses. The survey was to help determine which aspects of the conversion students' knowledge, achievements, and interactions were sufficient for coursework in the MS program and which aspects were deficient.

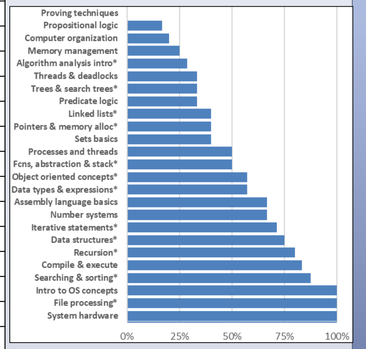
Instructor Agreement That Conversion Students are Achieving MS Program Learning Outcomes:

Outcome	Not necessary	Necessary	Agree	Neutral	Disagree
O1	2	7	6	0	1
O2	0	9	8	1	0
O3	1	8	4	2	2
O4	0	9	8	1	0

Instructor Agreement Conversion Students Demonstrate Sufficient Knowledge in 25 CS Areas: Table lists topics in NYU Tandon's CS online bridge to their CS MS program (not transition to a professional Computing program). Asterisk (*) indicates topic covered in COSMIC bridge course. Columns 2 & 3 indicate number of instructors who felt the topic was necessary for their course. If viewed as necessary, columns 4, 5 & 6 indicate whether instructors felt conversion students had the necessary background.

Topic	Not necessary	Necessary	Agree	Neutral	Disagree
System hardware	4	5	5	0	0
Number systems	3	6	4	2	0
Compile & execute	3	6	5	1	0
Data types & expressions*	2	7	4	2	1
Iterative statements*	2	7	5	1	1
Propositional logic	3	6	1	5	0
Predicate logic	3	6	2	4	0
Proving techniques	6	3	0	1	2
Sets basics	4	5	2	3	0
Algorithm analysis intro*	2	7	2	3	2
Fcns, abstraction, & stack*	3	6	3	2	1
Pointers & memory alloc*	4	5	2	1	2
Recursion*	4	5	4	1	0
Searching and sorting*	1	8	7	1	0
Object oriented concepts*	2	7	4	3	0
File processing*	2	7	7	0	0
Linked lists*	4	5	2	3	0
Data structures*	1	8	6	1	1
Trees & search trees*	3	6	2	2	2
Computer organization	4	5	1	3	1
Assembly language basics	6	3	2	1	0
Intro to OS concepts	4	5	5	0	0
Processes and threads	3	6	3	2	1
Threads & deadlocks	6	3	1	1	1
Memory management	5	4	1	2	1

Visualization of Instructor Agreement: If an instructor viewed an NYU Tandon CS bridge program topic as necessary for course (columns 3), percentage agreement that conversion students had necessary background (100%*column(4)/column(3)).



Discussion: The 25 topics in the instructor survey are taught to students in NYU Tandon School of Engineering's CS Bridge Program. NYU CS Bridge is wholly online and we have begun to consider moving at least part of our bridge course to an online format. One way to facilitate communication and sharing with NYU Tandon was to establish a common framework for program comparisons and collaborations. However, our overall program goals differ in that COSMIC has a professional MS focus.

Concluding Remarks: The instructor survey helped confirm COSMIC is successfully helping conversion students. Instructors are in an excellent position to judge how well the bridge course prepares students to achieve in the courses they teach. The instructors survey showed that instructors consider conversion students sufficiently prepared in 14 of 25 CS requisites for success in their courses, and that instructors consider conversion students to be completely deficient in only one. Furthermore, instructors believe that the conversion students in their classes are achieving all four of the primary learning outcomes of the MS program, although weak O3 achievement. However, these results are remarkable in view of the fact that the conversion students' formal preparation is far less than the formal preparation of traditional students, who constitute the overwhelming majority of the students enrolled in the MS program.

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