

Experiences Teaching Simulation in a Business Analytics Academic Program

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The university

- The University of Michigan - Ann Arbor is a large university (enrollment about 44,000) and partially state-supported
- The University of Michigan – Dearborn is the larger of two branch campuses (the other is University of Michigan – Flint), with enrollment now over 9,000
- Historically, the University of Michigan – Dearborn has been a “commuter school”
- Academic standards have benefited immensely with an influx of international students
- Housing has been built largely with international students in mind

Context

- Course taught within the College of Business
- Specifically, within the Business Analytics program for a Master of Science degree
- *Financial Engineer* recently rated this program #28 in the U.S
- 10 courses (3 credits each) required; six of these are core courses
- Students usually spend 2 academic years in the program
- 3 semesters (fall, winter, summer) per year
- Approximately, courses with 500-numbers are first-year; 600-numbers, second year

The core courses

- DS 520 - Applied Statistical Modeling
- DS 570 - Management Science
- DS 630 - Applied Forecasting
- DS 631 - Decision Analysis
- DS 632 - System Simulation
- DS 633 - Data Mining for Business Applications
- Of these, I have taught DS 520, DS 570, DS 631, and DS 632
- DS 520 or equivalent is prerequisite for DS 632

The prerequisite background

- DS 520 covers:
 - Basic data types (nominal, ordinal, interval, ratio)
 - Graphical data presentation
 - Numerical data summary (mean, median, standard deviation....)
 - Basic probability (union, intersection, complement, Bayes's Theorem....)
 - Several discrete distributions (Bernoulli, binomial, Poisson, hypergeometric)
 - Several continuous distributions (normal, exponential, uniform)
 - Construction of confidence intervals
 - Hypothesis testing (one and two populations)
 - Simple linear regression, with *perhaps* a glimpse into further regression methods

The students

- In a typical DS 632 class, half (or a few more) of the students are international (versus local)
- Our Dean Balakrishnan, originally from India, has established a strong partnership with VIT University, India
- This university sends us about 50 students a year
- These students are typically very intelligent, highly motivated, and hard-working
- They are also very brave in overcoming and adapting to culture shocks (plural! – next slides)

Culture Shock example – this tree is *not* dead



Culture Shock example – many locals will eagerly eat this



Culture Shock example – winter weather



Adaptation – “You’ll need these.”



Earning opportunities

- Many of these international students work on the campus as:
 - Graders
 - Tutors
 - Clerical assistants
- Visa restrictions typically preclude their working off-campus (e.g., as a server in a restaurant or a clerk in a store)

Typical DS 632 student background

- *Includes:*

- Firm grasp of statistics as taught in DS 520
- Strong knowledge of Microsoft Excel®
- Eagerness and capability to learn complex software
- Understanding of fundamental business and financial concepts

- *Usually excludes:*

- Knowledge of ANOVA and DOE
- Knowledge of logistic regression
- Ability to write computer programs
- Background in queueing theory

The DS 632 course “System Simulation”

- Taught twice a year: winter semester January-April (14 weeks) and summer second ½ semester July-August (7 weeks, twice as many class hours per week)
- Uses required textbook W. David Kelton, Jeffrey Smith, and David Sturrock. 2017. *Simio and Simulation: Modeling, Analysis, Applications*, 4th edition. Learning Solutions.
- Optional workbook Joines, Jeffrey A. and Stephen D. Roberts. 2015. *Simulation Modeling with Simio: A Workbook*, 4th edition. Simio® LLC.
- Tour of syllabus.

Three ways the course is *un*realistic

- I state these three ways the very first class session:
 1. The models built in this course will be small
 2. The data for homework exercises will be given to you
 3. After building one model for one topic, you will set it aside and build a new one for another topic

Software used

- @RISK[®], for the introduction of static simulation
- Simio[®], for dynamic discrete-event process simulation (the major part of the course)
- Stat::Fit[®], for distribution fitting

Simio[®]

- *SIM*ulation using *I*ntelligent *O*bjects
- Constructs include Source, Sink, Server, Worker, Vehicle, Combiner, Separator
- Very helpful verification aids (traces, snapshots, stepwise execution)
- Excellent interface design of the software encourages complete verification and validation before undertaking experimentation
- Commendably easy exploration and comparison of many system alternatives
- Aggressive, helpful support (responses usually within 12 hours)

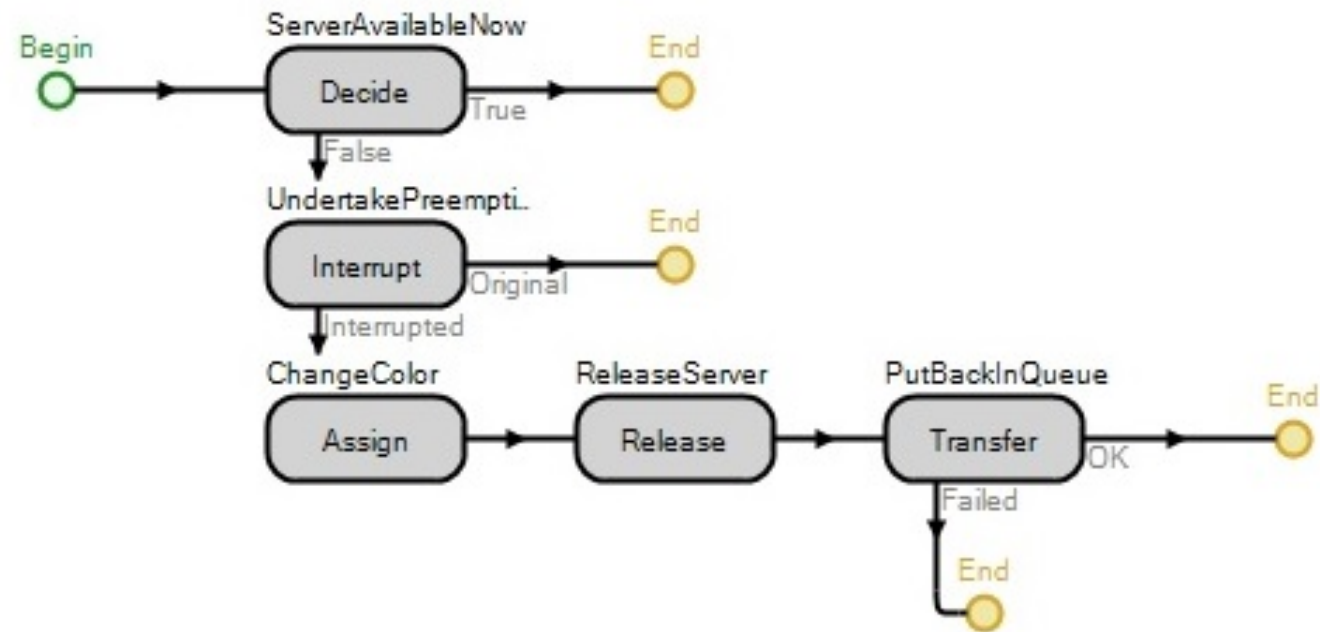
Advantages of Simio[®]

- Easy to get started on
- High power
- Good internal help
- Many small examples (“SimBits”) for student self-study
- Updates several times a year
- Vitally important: “code” by point-click-drag (next slide)
- ❖ But: Required textbook could easily and profitably triple in size and coverage

Example of Simio[®] “Code”

Server1 Add-On Processes

Server1_Entered



Animation

- Yes, Simio[®], like its competitors, has the ability to produce lovely animations (both 2D and 3D) readily
- I vigorously downplay the importance of a lovely animation, which pales in relation to the importance of a verified, validated model

Sequence of Course Assignments

- A formula-based queuing problem, based on Kendall's notation
- A static financial simulation, using @RISK®
- Several basic Simio® modeling assignments (class examples in Simio® include an ice-cream counter, a basic assembly line, use of vehicles in a small assembly line, and use of workers in an urgent-care clinic)
- A term project (deliverables are a Simio® model, a written report on project scope, approach to work, and analysis of results), and an oral report to the class (using MS PowerPoint®)
- ❖ All these assignments are done in teams (3 to 5 students); the students select their teammates

Favorable comments are frequent

- I wish there was a follow up course where you could really dive into the software. Poisson process – perhaps the basic math behind it. It's been skipped altogether or lightly covered in every stats class I've ever taken (I think I've taken 4 at this point).
- Queue Theory, I've never given it much thought, but it's an incredibly interesting topic.
- This course is very useful. The Simio® application will be very useful when we start working in Corporate world.
- I LOVED this class. I wish I could take another course in Simulation and learn even more about it.

Conference papers spawned by this course

- Gruber, Jared W., Renée Smiddy, Jeffrey M. Watson, and Edward J. Williams. (2015). Simulation Helps Local Grocery Store Compete Effectively Against Large Chains. In *Fifth International Conference on Industrial Engineering and Operations Management* (ISBN 978-0-9855497-2-5, pages 2421-2424).
 - Sivaramakrishnan, Sapthagirishwaran Thennal, Shanmugasundaram Chandrasekaran, Jennifer Dhanapal, Paul Ajaydivyan Jeya Sekar, and Edward J. Williams. 2016. Simulation Improves Operations at a Specialized Takeout Restaurant. In *Proceedings of the 30th European Conference on Modelling and Simulation*, eds. Thorsten Claus, Frank Herrmann, Michael Manitz, and Oliver Rose, 59-65.
- ❖ These papers were expanded from student term project reports

Questions and Discussion

