INFORMS Computing Society: Panel Discussion on Education

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Our Charge

- We were asked to outline appropriate curricula for undergraduate students planning to pursue work at the OR/CS interface.
- We determined that the best approach is to outline a list of skills, rather than a list of courses.
  - Tier One: skills deemed essential for future success at the OR/CS interface
  - Tier Two: skills deemed important for future success, but not essential
  - Tier Three: skills deemed helpful in work at the OR/CS interface, but not necessary for success
- Note: We are not making curricular recommendations for individual programs/departments.

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## Tier 1 - Mathematics Competencies

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<th>Calculus</th>
<th>Linear Algebra</th>
<th>Discrete Math</th>
<th>Prob. &amp; Stats</th>
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<td>Linear Systems - solving,</td>
<td>Set Theory</td>
<td>Basic Prob.</td>
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<td>independence,</td>
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<td>Sequences/Series</td>
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<td>Linear Regression</td>
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Tier 1 - Operations Research Modeling

- Ability to create a mathematical model describing a particular situation or application
- Ability to separate model from data
- Know methods and software available to solve models
- Ability to interpret, analyze, and communicate model solutions

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**Tier 1 - Continued**

- **Technical Writing and Presentation**
  - Ability to organize and support analysis and convincing arguments (e.g. mathematical proofs, statistical analysis)

- **Basic Computing Competencies**
  - Familiarity with Contemporary Operating Systems (e.g. Windows, Unix, etc.)
  - Experience using general scientific software (e.g. Matlab, Maple, SPSS, SAS, etc.)
  - Experience using spreadsheet and other Office-type packages

- **First-year Programming Competencies**
  - Fluency in a compiled computer programming language (e.g. C, C++, Java)
  - Familiarity with scripting languages (e.g. Python, VBA, optimization modeling languages)
  - Familiarity with common data structures (e.g. linked lists, stacks, queues, heaps, trees)
  - Ability to analyze run-time of basic algorithms

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Tier 1 - Awarenesses

- Numerical Analysis
  - Difference between computed and analytical solutions
  - Awareness of error analysis
  - Round-off error
  - Errors in approximation techniques

- Operations Research Modeling
  - Familiarity with various model types and their applications
  - Mathematical programming models
  - Simulation models
  - Analytical probability models
  - Ability to choose appropriate model type for a given application (e.g. understand the difference between capabilities of simulation and mathematical programming).
  - Determine whether exact or heuristic methods are most appropriate in solving a model
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Tiers 2 & 3 - Mathematical Competencies

- Differential equations
  - ODEs & PDEs
  - solution methods

- Advanced/Numerical Linear Algebra
  - conditioning and stability
  - SVD
  - QR factorization
  - Cholesky factorization

- Numerical analysis / scientific computing
  - floating point calculations
  - numerical integration
  - numerical solution of differential equations

- Real analysis
  - More advanced graph theory
  - Knowledge of mathematical proof writing techniques

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Tiers 2 & 3 - OR Theory, Modeling & Algorithms

- Understand the differences between exact methods and heuristics
- Understand the differences between feasibility, local optimality and global optimality
- Basic ability in formulating models (mathematical programming, simulation, probabilistic, etc.)
- Some experience in designing solution methods for models
- Linear programming
  - duality, simplex algorithm
- Familiarity with various algorithm types and corresponding model-types for application
  - branch-and-bound / enumeration / tree search
  - gradient-based methods (for nonlinear)
  - dynamic programming
  - stochastic optimization methods
  - different types of heuristics
- Some exposure to IE topics such as supply chain management, scheduling, logistics, production, controls, etc.

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Tiers 2 & 3 - Continued

- Computing Competencies:
  - Proficiency in using both Windows and UNIX/Linux operation systems
  - Experience w/ a mathematical programming language (GAMS, AMPL, AIMMS, etc.)

- Programming Competencies:
  - Fluency in object-oriented computer programming
  - Compiling code in different environments / operating systems
  - Scripting language experience (Perl, Python, etc.)
  - Basic conceptual knowledge of parallel computing
  - Exposure to software design principles
  - More advanced competency in algorithmic analysis & computational complexity
  - Big-O notation
  - algorithm design
  - algorithmic analysis

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