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Overview of Computational Science and Engineering Education Programs

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XSEDE

Extreme Science and Engineering Discovery Environment

The Need For Computational Scientists

- A number of national studies document the need for computational scientists
  - …" computer modeling and simulation are the key elements for achieving progress in engineering and science." NSF Blue Ribbon Panel on Simulation-Based Engineering Science
  - "A persistent pattern of subcritical funding overall for SBE&S threatens U.S. leadership and continued needed advances…" International Assessment Of Research And Development In Simulation-Based Engineering And Science
  - Nearly 100% of the respondents indicated that HPC tools are indispensable, stating that they would not exist as a viable business without them or that they simply could not compete effectively. IDC Study for Council on Competitiveness of Chief Technology Officers of 33 Major Industrial Firms

Examples of Modeling Problems

- Tracing the spread and evolution of disease (http://supramap.osu.edu/
- Collaborations to explore historical and contemporary events and social interaction (http://www.ichass.illinois.edu/Projects/Projects.html)
- Predicting the impacts of earthquakes (http://nees.org/)
- Designing and testing new nanomaterials and devices (http://nanohub.org/)
- Discovering oil reserves (http://access.ncsa.illinois.edu/Stories/oil/)
- Designing new packaging (http://phx.corporate-ir.net/phoenix.zhtml?c=104574&p=irol-newsArticle&ID=651774&highlight)
- Discovering how the brain works (http://www.compete.org/publications/detail/503/breakthroughs-in-brain-research-with-high-performance-computing/)

XSEDE Education Program Goals

- Prepare the current and next generation of researchers, educators and practitioners.
- Create a significantly larger and more diverse workforce in STEM.
- Inculcate the use of digital services as part of their routine practice for advancing scientific discovery.

XSEDE Education Program Services

- Campus Visits
- Assistance with program creation
- Workshops for faculty and students
- Repository of shared materials
- Other resources

Initiating Services to Facilitate Change

- Campus visits
  - First discussions about integrating computational science into the curriculum
  - Discussion of formal programs
  - Opportunities for faculty professional development
  - Overview of related XSEDE services

Promoting Formal Academic Programs

- XSEDE Education program is focused on assisting with the initiation and enhancement of formal computational science and engineering programs
  - Both undergraduate and graduate programs
  - Most sustainable way to help achieve the long-term project goals by producing a savvy workforce
  - Reduce the barriers to program adoption by
    - Providing program models
    - Solidifying a virtual community to share experiences
    - Providing faculty professional development

Creating Computational Science Programs

- Inherently interdisciplinary
  - Science, engineering, or social science domain
  - Mathematics
  - Computer science
- Expertise often dispersed across multiple departments, colleges, institutions
- Difficulty of negotiating requirements, responsibilities, and institutional arrangements

Providing a Curriculum Model

- Based on our experience in Ohio creating an interdisciplinary, inter-institutional minor program in computational science
- Effort supported by an NSF grant
- Allowed us to work through many of the issues associated with creating an interdisciplinary program
- Demonstrated the feasibility of an interdisciplinary, inter-institutional program
- See http://hpcuniversity.org/educators/competencies/

Program Requirements

- Created a competency-based curriculum
  - Provides detailed outlines of the background and skills desired for students completing the program
  - Bridged the differences across disciplines
  - Allows for flexibility in implementation to fit the program into multiple institutional situations and majors with different backgrounds and focus areas
- Serves wide range of needs
  - Provides essential skills for all students regardless of whether they complete the minor

Undergraduate minor program overview

- Undergraduate minor program
  - 4-6 courses
  - For majors in variety of fields
- Faculty defined competencies for all students
- Reviewed by business advisory committee
- Currently being updated to reflect changes in hardware and software technologies
- Requirements adjusted to reflect the needs of different majors

Competencies for Undergraduate Minor
Simulation and Modeling
Programming and Algorithms
Differential Equations and Discrete Dynamical Systems
Numerical Methods
Optimization
Parallel Programming
Scientific Visualization
One discipline specific course
Capstone Research/Internship Experience

Flexibility in Implementation

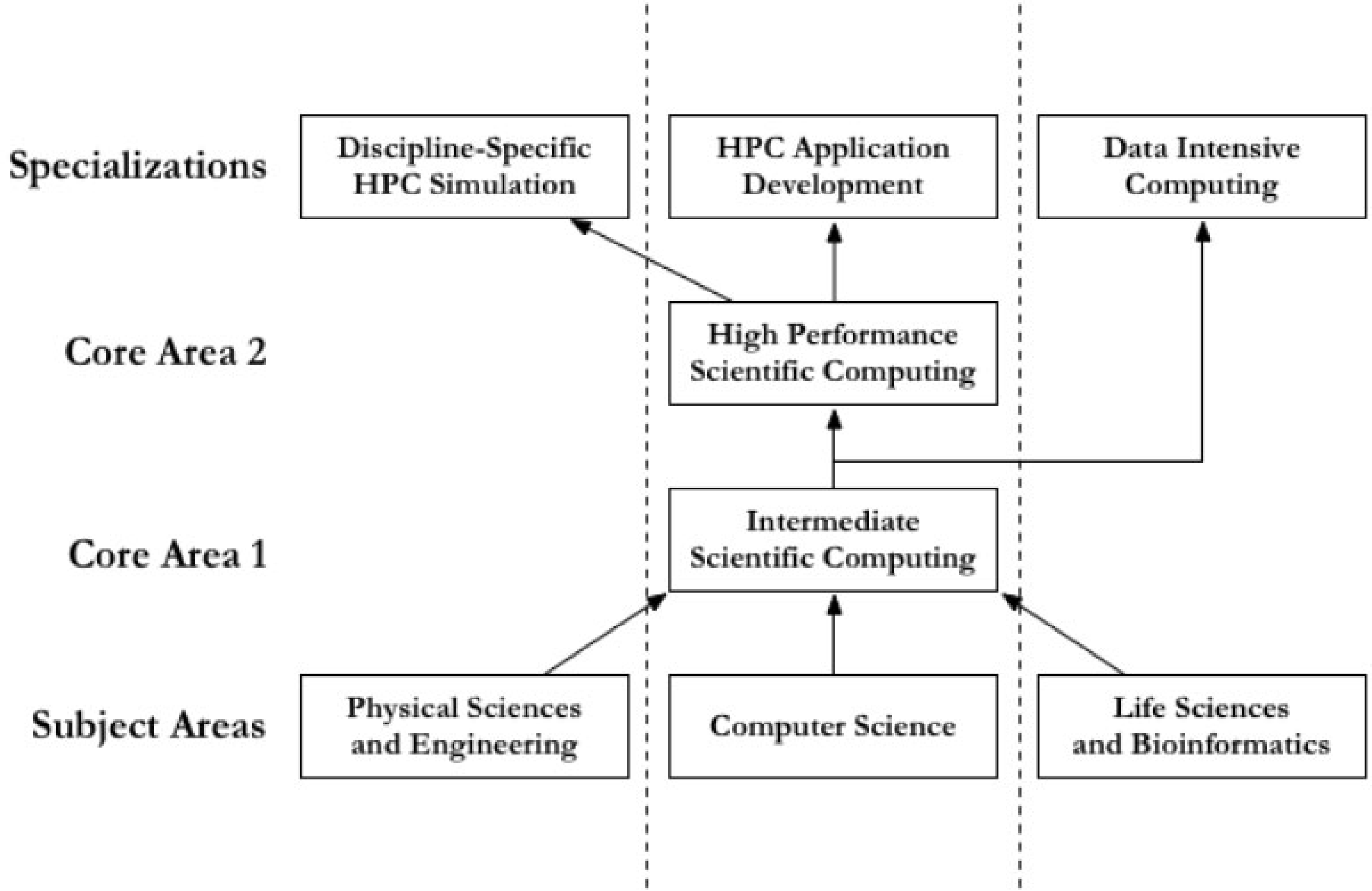
- Adapt existing courses by adding computationally oriented modules or focus on new target audience
- Discipline oriented courses dependent on existing faculty expertise and interests
- Different subsets of required and optional competencies tied to major, required math, and example projects

Community College Program

- Created competencies for science majors in two-year schools along with a concentration in computational science
  - http://www.rrscs.org/associate
  - Program at Stark State College in Ohio
    - http://www.starkstate.edu/academic-programs/computational-science

Graduate Level Competencies

- Assumes some of the background of an undergraduate
- Focus more on research skills
- Core areas focus on the computer science and related modeling skills
- Need to branch into a wider array of specializations based on the nature of the graduate program


Specializations
Core Area 2
Core Area 1
Subject Areas
Discipline-Specific HPC Simulation
HPC Application Development
Data Intensive Computing
High Performance Scientific Computing
Intermediate Scientific Computing
Physical Sciences and Engineering
Computer Science
Life Sciences and Bioinformatics

Developing Faculty Expertise

- Faculty professional development workshops
  - Two to six day workshops on a variety of topics
    - Computational thinking
    - Computational science education in science and engineering domains
  - Focus on local/regional audiences to reduce travel costs
  - Subsidies for faculty to travel to workshops at other sites

Special Workshops for Faculty and Students

- Development of synchronous and asynchronous education and training sessions
  - Multi-site broadcasts of workshops
  - Online training and education modules
  - Experimenting with full courses that can be widely shared for credit and non-credit inclusion in curricula (e.g. https://www.xsede.org/xsede-offers-free-online-parallel-computing-course)

Repository of Shared Materials

- Developing a repository of computational science education materials
  - Reviewed by professional staff and faculty
  - Indexed by subject and a detailed competency-based ontology
  - Goal: trusted, comprehensive source of information for computational science educators
  - http://hpcuniversity.org/resources/search/

Some Other Opportunities

- Journal of Computational Science Education
  - www.jocse.org
  - Peer reviewed article on computational science education experiences
- Become a reviewer or contributor to the online repository
- Use the XSEDE online materials
  - www.xsede.org

Questions and Discussion