



Integration of CFD into the Chemical Engineering Undergraduate Curriculum:

A Report from the CACHE CFD Task Force

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DEM Solutions

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Outline

- Who are we?
- What is CACHE?
- CACHE CFD Task Force
- Integrating CFD into ChE curriculum
 - Michigan State success story
- Why hasn't CFD been adopted broadly in ChE undergraduate curriculum?
- Path Forward

Charles Petty – Educational Goals



- Develop a new curriculum for undergraduates and graduates for MTP/CFD ... computational transport phenomena (CTP)
 - Fundamentals of multiphase transport phenomena
 - Formulation & evaluation of multiphase models
 - Fundamentals of numerical methods
 - Application of CFD codes for non-turbulent and turbulent flows
 - Application of CFD codes for single phase and multiphase flows
 - Integrate CFD into engineering design
-
- 1990-1995, Hydrocyclone Development Consortium (Arco, Amoco, Exxon, Chevron, Texaco, Marathon, Krebs Engineers, Monosep, U. S. Navy, DOE)
 - 1999-2002, NSF/CRCRD
 - 2004-present, NSF I/UCRC for Multiphase Transport Phenomena (Adapco, Bechtel, Chevron, Fluent, Petrobras, and Pfizer --- MSU, UAkron, UTulsa, & UCF)

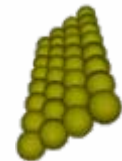
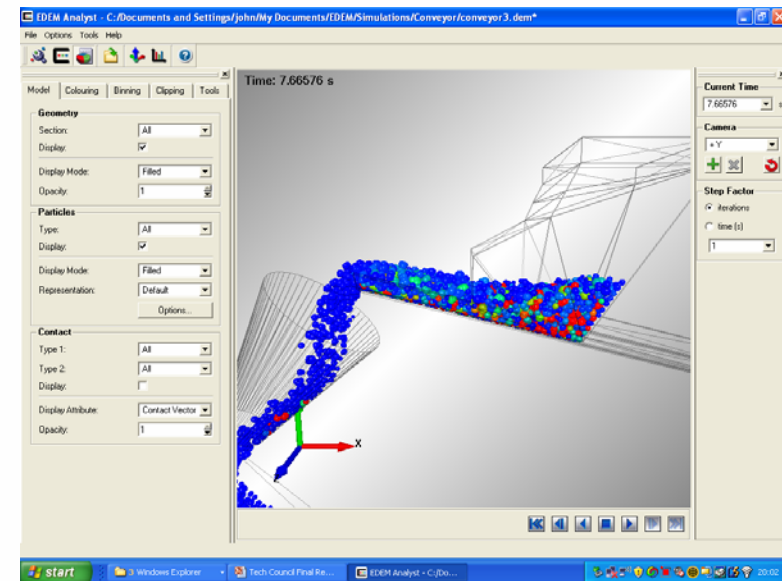
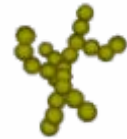


Richard LaRoche - Background

- Chemical companies
 - Dow Chemical
 - DuPont
 - Fluid flow & mixing consultant
- Technology companies
 - Cray Research
 - Focused on CFD application to chemical industry
 - Fluent
 - Including stint as University Program Manager
 - Initial FlowLab deployment
 - ANSYS
 - DEM Solutions
 - Responsible for all Engineering including University Program
- Academia
 - Penn State (Assistant Professor)
 - University of Delaware (Adjunct Faculty)
 - Dartmouth College (Visiting Professor, Bioreactor Research Collaborator & Ph.D. Thesis Committee)

Discrete Element Method (DEM)

- Models the interaction between each discrete object/element or “particle” and
 - Other particles
 - Objects under kinematic control
 - Surrounding media and force fields (fluid, electromagnetic)
- Accounts for particle size, shape and mechanical properties
- Solves at the particle scale
- Computes the dynamics of each object
- Couples with CFD, FEA and MBD





CACHE Corporation

Computer Aids for Chemical Engineering Education

- Non-profit organization founded in 1969
- Promote computer-based tools & technology in the chemical engineering field
 - Enhance chemical engineering instruction
 - Enhance productivity of chemical engineering students, educators and practitioners
- Initial mission was software creation
- Current mission
 - Module creation using commercial tools
 - Chemical Engineering CAE conferences



CACHE works with:

- 140 ChE Departments
- 28 Trustees
- 12 Industrial Affiliates
- Professional Societies such as AIChE and ASEE
- www.cache.org
- National Science Foundation
 - Chemical engineering education grants



CACHE Task Forces

- CFD
- Fuel Cells
- Molecular Modeling
- Virtual Control Book
- Sustainability
- Systems Biology



CACHE CFD Task Force Members

- Brigette Rosendall, Bechtel
- Bruce Finlayson, U. Washington
- Charles Petty, Michigan State
- Gavin Towler, UOP
- Jim Tilton, DuPont
- Jennifer Curtis, U. Florida
- Kurt Svihla, ANSYS
- Laura Dietsche, Dow
- Paul Sechrist, UOP
- Richard LaRoche, DEM Solutions
- Rodney Fox, Iowa State
- Shane Moeykens, ANSYS
- Tom Hanley, Auburn
- Venkat Raman, U. Texas
- Willis Bell, Eli Lilly



Task Force Activities

- Monthly WebEx meetings
- Define teaching module specifications
- Survey existing CFD teaching module material
- Create a working list of proposed teaching modules
 - Academic lead
 - Industrial mentors
- Explore why past CFD teaching module projects have fell short of goals
- Explore how CACHE can help

344b: Integrating Computational Transport Phenomena into the Undergraduate Chemical Engineering Curriculum

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²The Department of Mechanical Engineering

Michigan State University, East Lansing, MI 48824

Nilesh Gandhi, Ajay Parihar, and Shane Moeykens

Ansys-Fluent, Inc.

Lebanon, New Hampshire 03766

344: Free Forum on Engineering Education I

8:57 A.M. Wednesday, 15 November

Van Ness (Hilton San Francisco)

2006 AIChE Annual Meeting

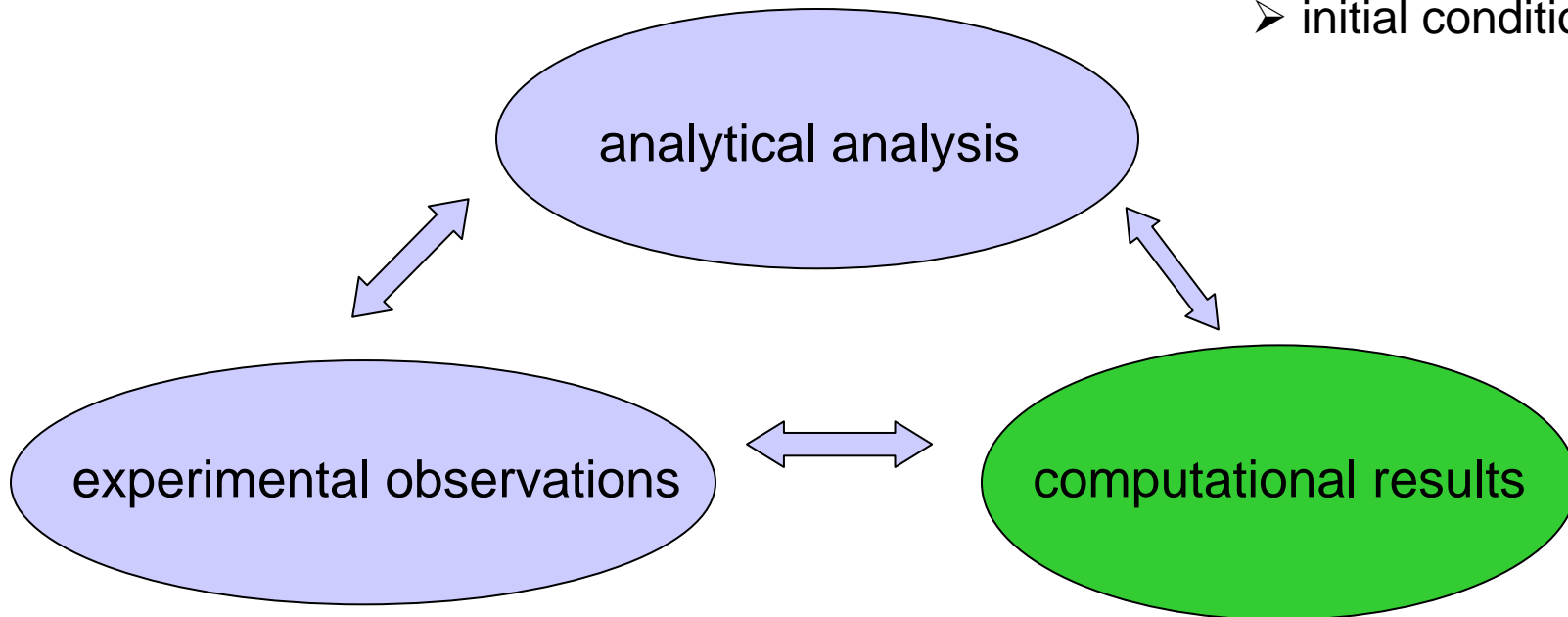
Scope of the CTP Training

- **Freshman** --- Frontiers in Chemical Engineering, Professor D. Miller
Dimensional Analysis --- unsteady state heat transfer
- **Sophomore** --- Introduction to Transport Phenomena, Professor B. Ofoli
Developing Flows --- entry length at low Reynolds numbers
- **Junior** --- Fluid Flow, Professor I. Lee
Engineering Analysis --- flow losses and toroidal recirculation flows
- **Senior** --- Independent Study, Professor C. Petty
- **Group Projects** --- I/UCRC-MTP, Professors A. Benard and C. Petty

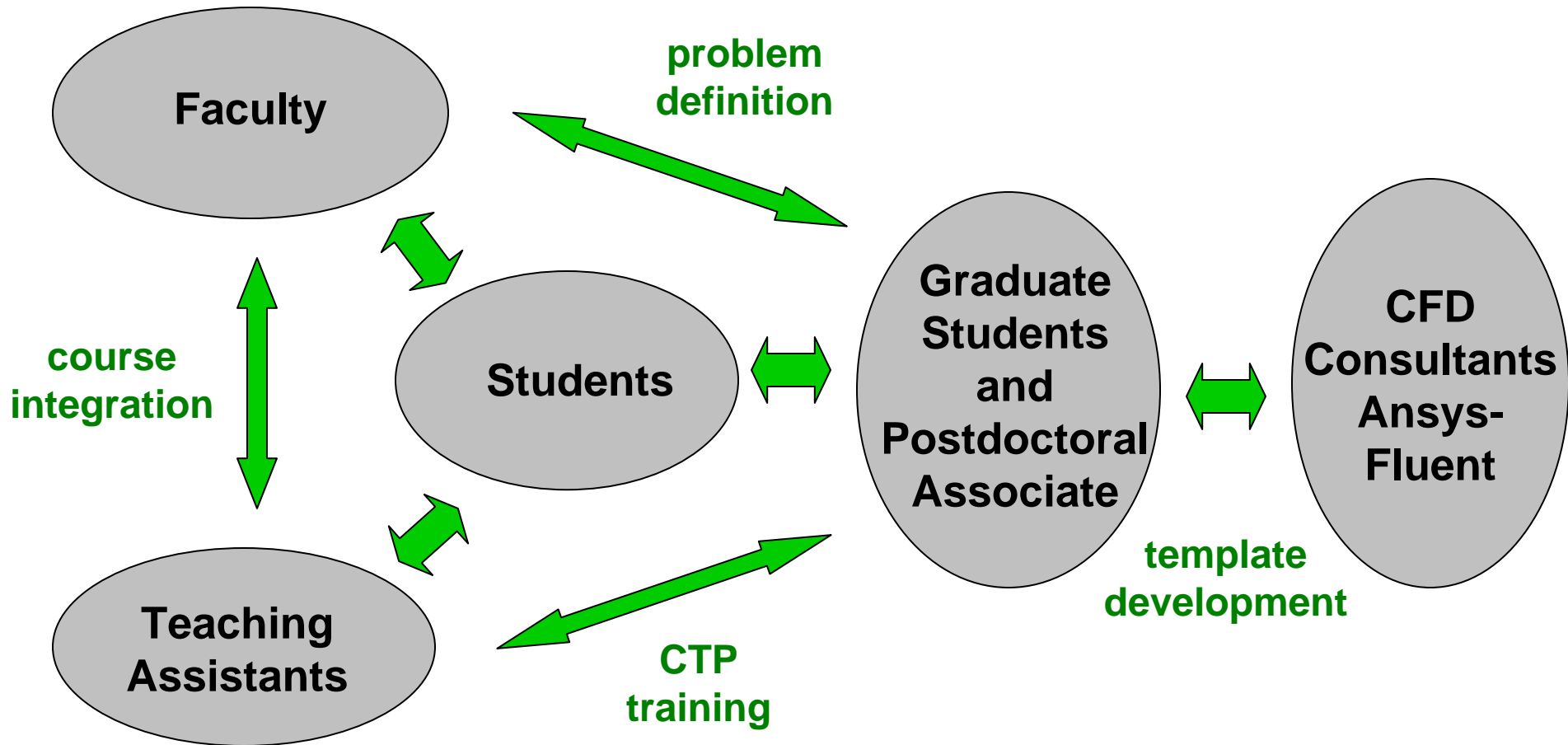
CTP Training --- Emphasis on Understanding, Discovery, and Excitement

Complementary to Course Lecture Topics Related to Momentum, Energy, and Mass Transfer

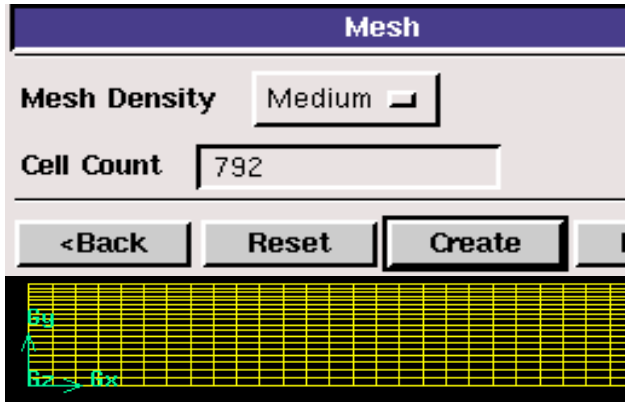
- geometry
- balance equations
- transport models
- material properties
- boundary conditions
- initial conditions



CTP Teaching Team at Michigan State University

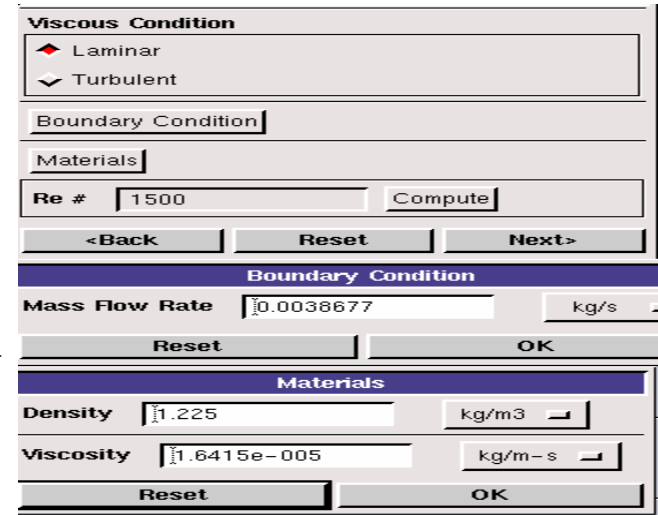


Components of the Training Tool, FlowLab®



Geometry and mesh

Physics

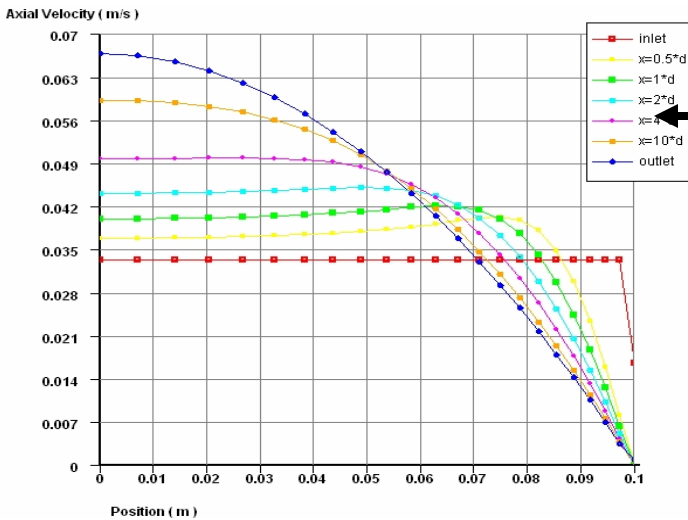
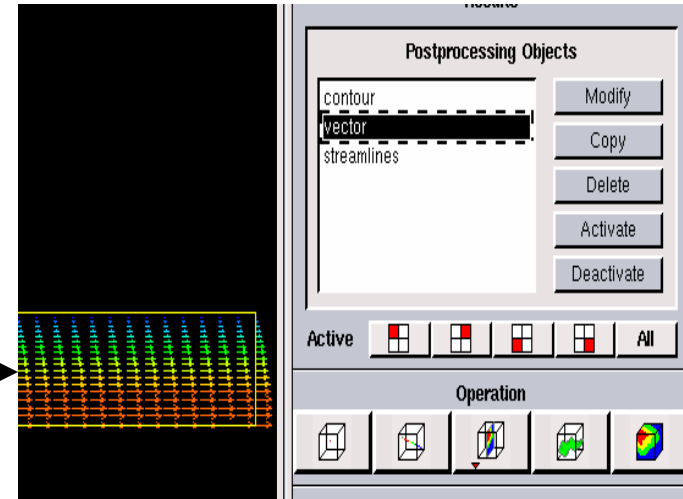


computes until convergence occurs (or the maximum number of iterations reached)

Solve

Reports

Post-processing



What are the Critical Success Factors to Deploying CFD in the ChE curriculum?

- Lack of CFD teaching modules?
 - More material is probably still needed but dissemination and integration into curriculum is not happening on a broader scale
- Key to success at Florida, Michigan State, Iowa, Iowa State was having a resident student coordinator coupled with a faculty mentor
 - Graduate student teaching assistant or undergraduate honors project
 - This “student helper” assists faculty in implementing modules in undergraduate courses
- Central repository for dissemination and maintenance of teaching modules



Path Forward

- CACHE CFD Task would like to explore collaboration opportunities with the “ISTEC Community”
- Informal collaborations
- Contribution of teaching modules
- Pursuing educational grant funding