Nanotechnology/ Nanofabrication: An Emerging Field Whose Time Has Come

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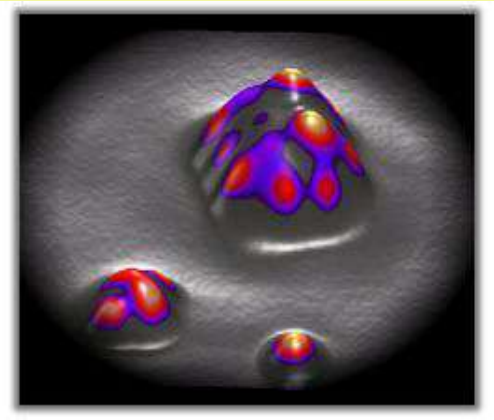
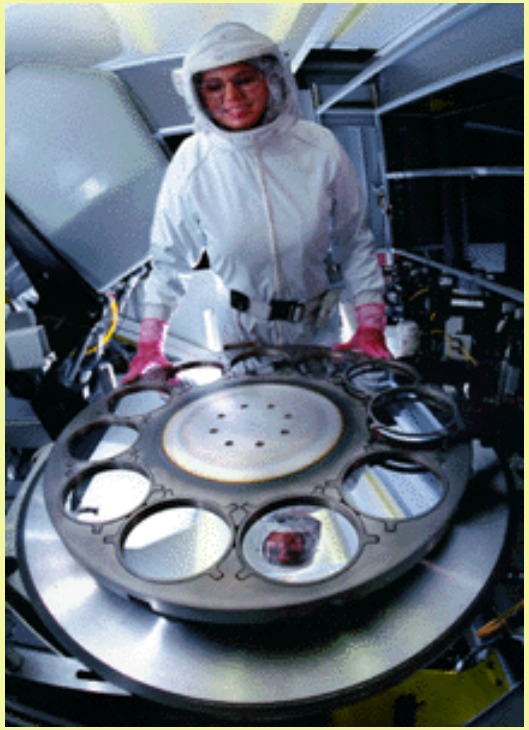
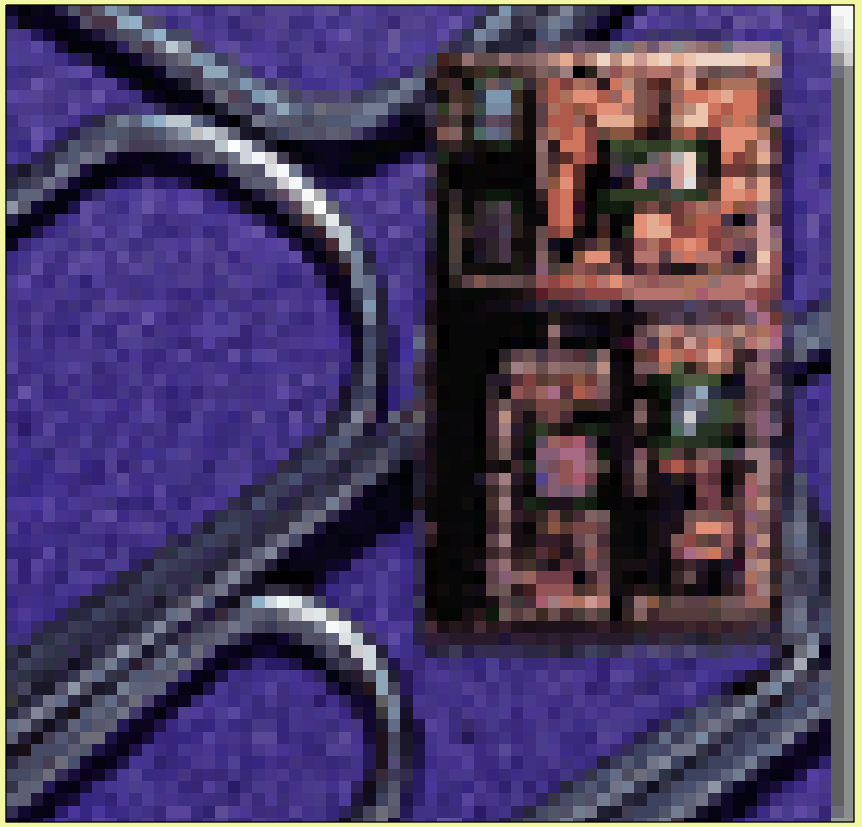
“If I were asked for an area of science and engineering that will most likely produce the breakthroughs of tomorrow, I would point to nanoscale science and engineering.”



April 1998, Neal Lane, Assistant to the President for Science and Technology and former Director of the National Science Foundation

What is Nanotechnology and Nanoscience?





NANO comes from the Greek word Nannos meaning dwarf

As a metric prefix it is a billionth of any unit
Or 10^{-9}

Major Metric Prefixes

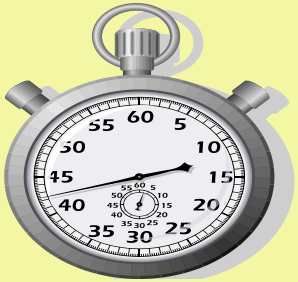
1,000,000,000	Giga	10^{+9}
1,000,000	Mega	10^{+6}
1,000	Kilo	10^{+3}
	Base unit	
0.001	milli	10^{-3}
0.000001	micro	10^{-6}
0.000000001	nano	10^{-9}

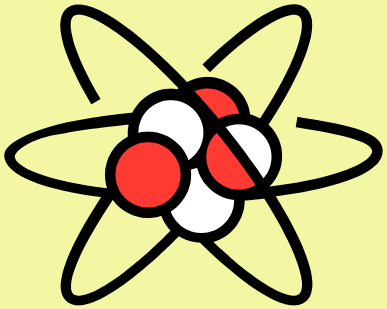
A nanosecond

A nanoliter

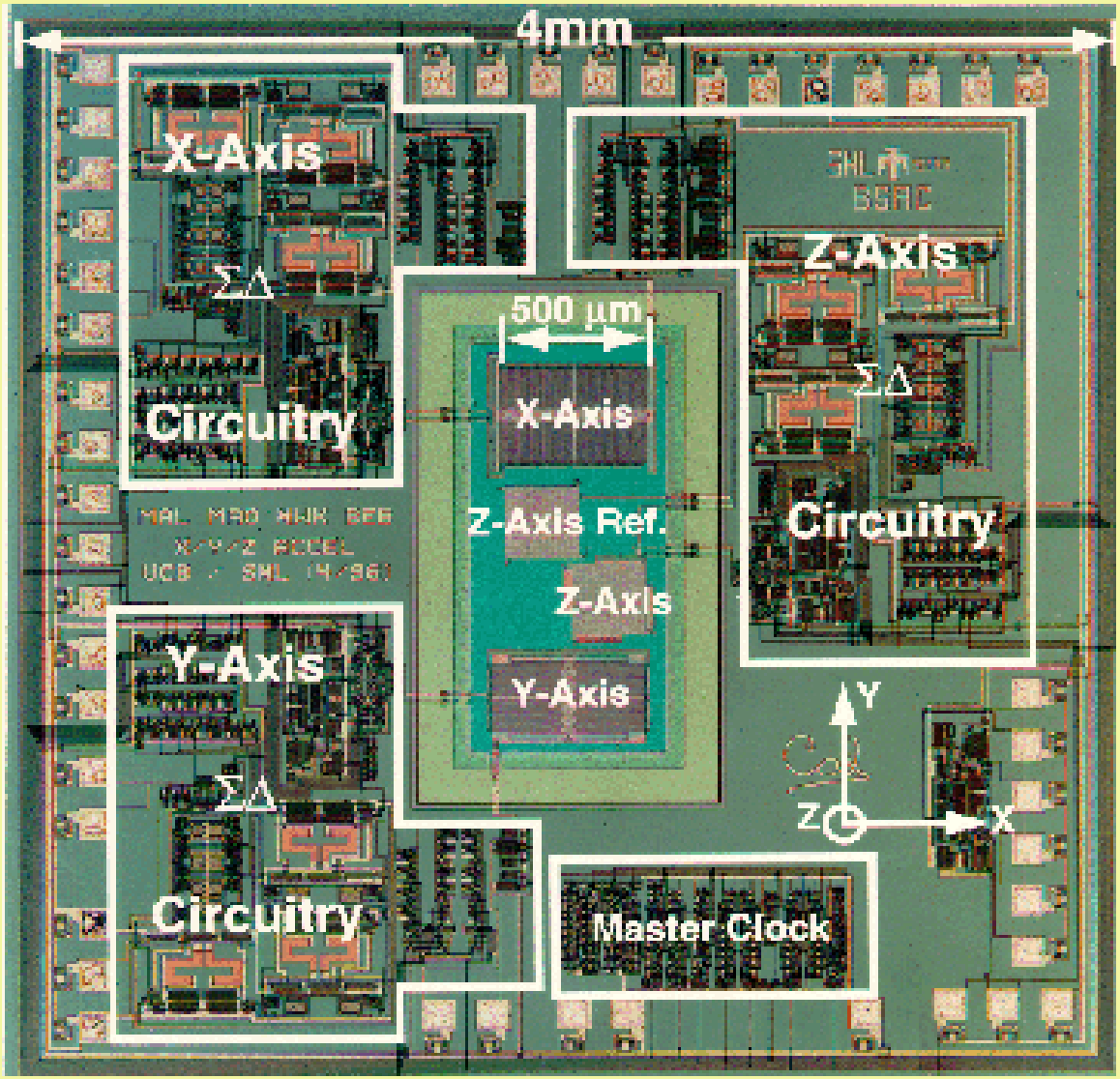
A nanometer

A nanogram





Air Bag
Trigger Circuit
with 3-D
Accelerometer

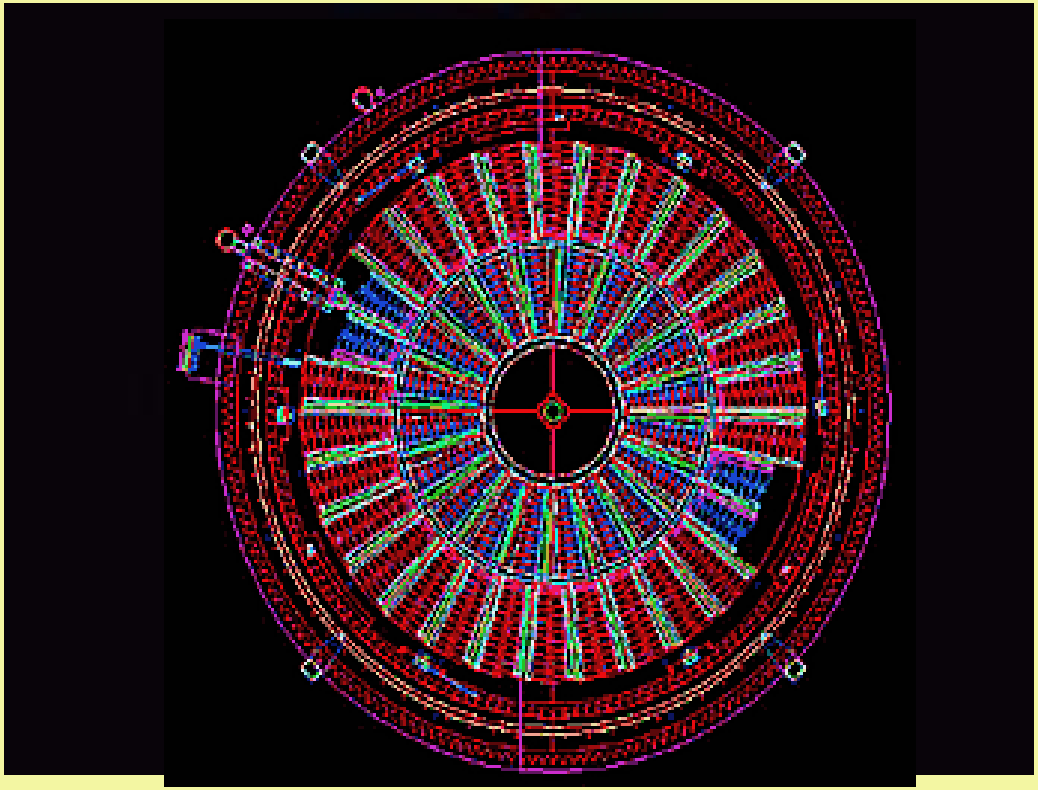


Nanofabrication is used in:

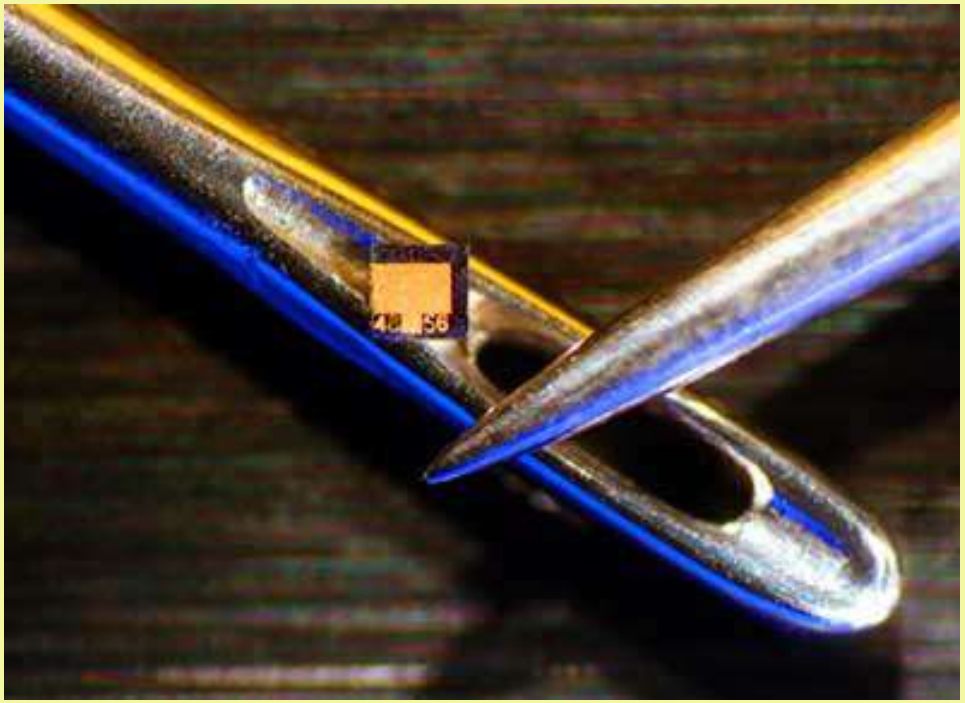
- Information storage
- Opto-electronics
- Sensors
- Micro-electro-mechanical (MEMs) devices
- Power semiconductors
- Pharmaceuticals
- Bio-medical applications
- Microelectronics (chips)

Nanoscience and nanotechnology generally refer to the world as it works on the nanometer scale, say

from
one nanometer to several hundred nanometers.

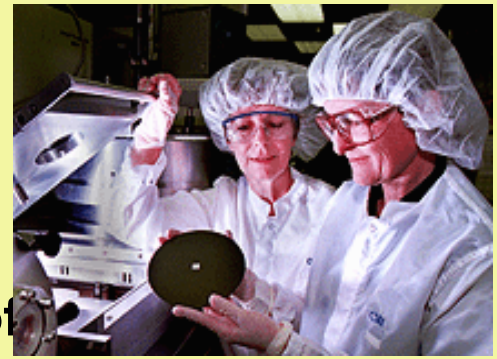


The Intel Corporation announced that it can make a transistor 20 nanometers long containing features only 3 atoms thick!



History of Nanofabrication Manufacturing Technology Partnership in Pennsylvania

- 1999 NMT Partnership begins with 6 community colleges
- Oct, 2001 Inauguration of Center for Manufacturing Education in Nanofabrication – involving all 14 Community Colleges , 4 Penn State campuses, Pennsylvania College of Technology, Pennsylvania State System of Higher Education
- 2002 and 2003 Two meetings per year
- 0ver 240 completed the Nano sequence



National Picture of Nano-Programs

BS Programs

- Arizona State University
- Ball State University
- California Institute of Technology
- Duke University
- University of Florida
- University of Maryland
- University of Texas-Austin
- University of Chicago
- University of Applied Sciences – Fachhochshule, Munchen
- McGill University
- University of Toronto
- University of Australia

PA Programs

NMT Partnership

Programs Within Pennsylvania

- Penn State University
- California University of Pennsylvania
- Clarion University
- Shippensburg University
- Indiana University of Pennsylvania
- Lock Haven University
- Pennsylvania College of Technology

PA Community Colleges

- Community College of Allegheny county
- Bucks County Community College
- Butler County Community College
- Cambria County Community College
- Community College of Beaver County
- Northampton County Community College
- Reading Area Community College
- Community College of Philadelphia
- Delaware County Community College
- Harrisburg Area Community College
- Lehigh Carbon Community College
- Luzerne County Community College
- Montgomery County Community College
- Westmoreland County Community College

CCAC Approach

Each School has the freedom to develop unique programs to fit their school

What factors went into the CCAC program?

Incorporation of Emerging Technologies into Existing Curriculums

- "Today, business and education are locked in a strategic stalemate. Educators are not always certain what industry wants. And with technology advancing so rapidly, industry often does not know what it needs. This situation makes our jobs more challenging."
G. Sehi, Dean, Sinclair Community College, (Fall, 1998)

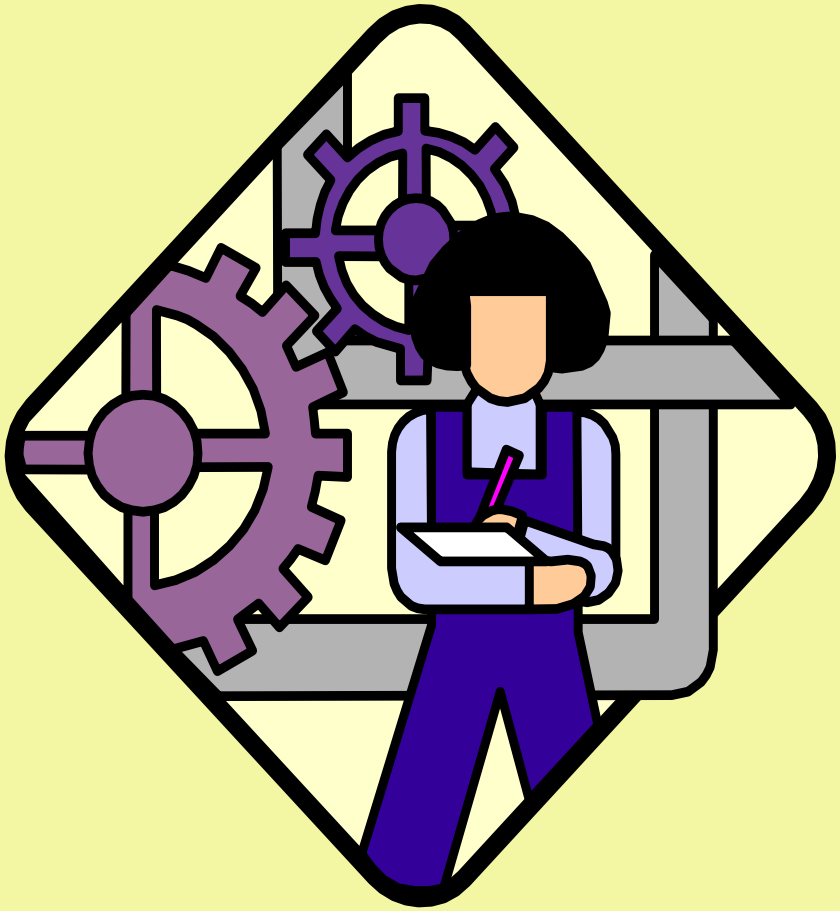
Skill Set

Mechanical Skills
Electrical Skills
Problem Solving
Project Management
Laboratory Analytic Skills
Written & Oral Communication
Flexibility
Sense of Urgency
Team Player
Listening Skills

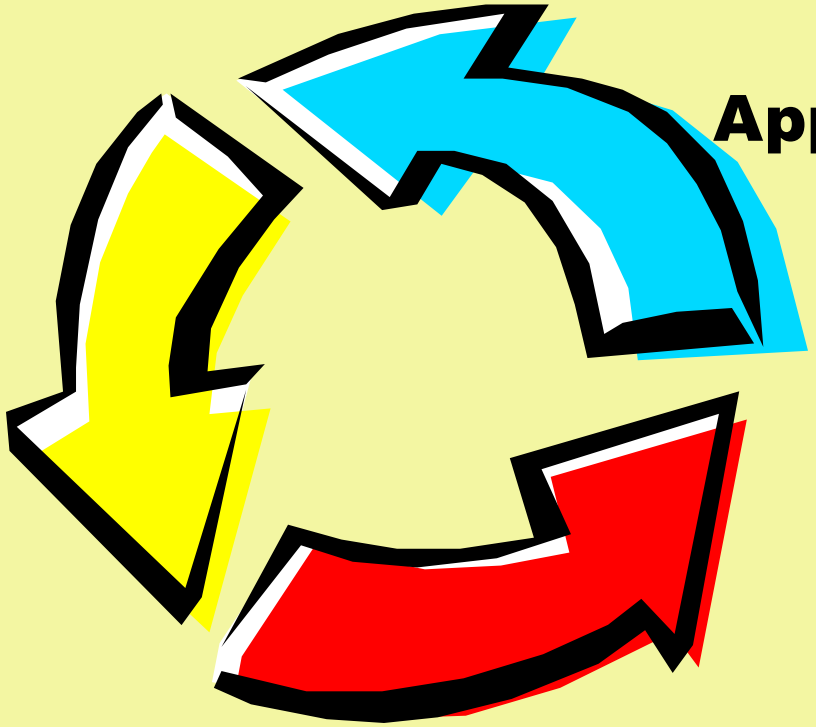
Organization
Material Science
Chemistry
Plasma & Optical Physics
Surface Science
Safe Work Practices
Creativity
Inventive
Materials Characteristics
Experimental Design

Advanced Manufacturing Academy

- Emphasis on real-world problems
- Apply systemic change to manufacturing related programs
- Impact - Physics, Mathematics, English and Technology



The Engineering Learning Cycle



Strategies for Application of Cognitive Studies to Curriculum Design

- 1. Reduce memory load.
- 2. Activate existing knowledge structures.
- 3. Representation of new knowledge techniques.
- 4. Encourage "deep thinking".
- 5. Enhance cognitive control processes.
- 6. Support the use and transfer of knowledge and skills.

(Johnson and Thomas, 1994)

Principles of Cognitive Studies

- 1. Organize into mental models(Student must build their own)
- 2. It is easy to learn what matches our mental model
- 3. It is hard to change our existing model(Telling will not change a student's model)
- 4. Every student has a different model for the same information

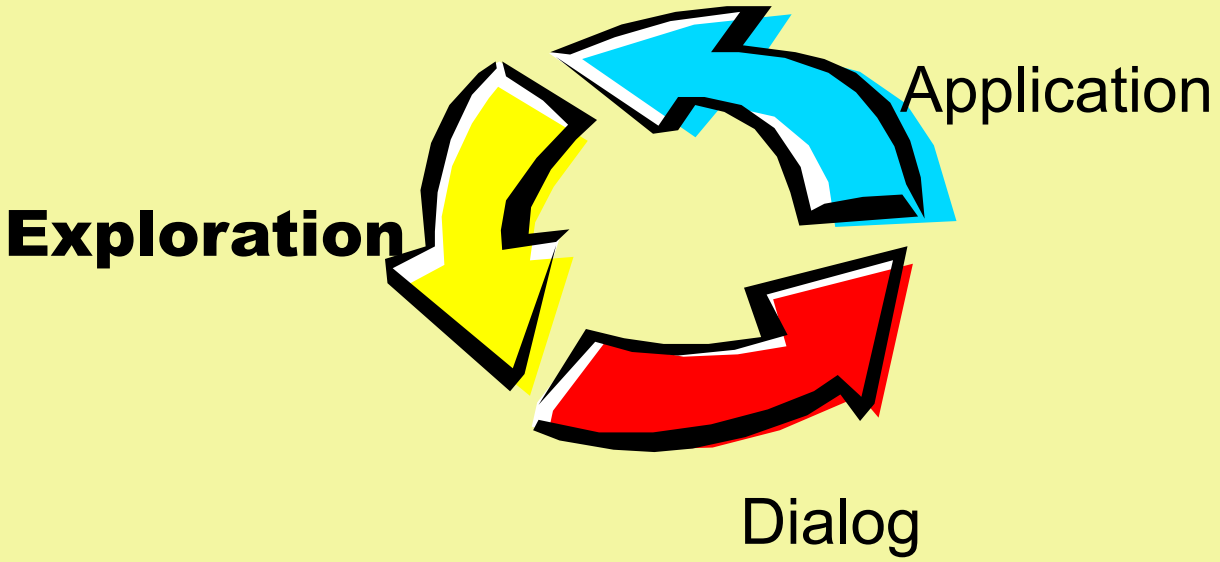
(Redish, 1994)

Basic Features of Adult Education

- 1. Related to work
- 2. Includes prior training
- 3. Immediate feedback through hands-on activities(Knowles, 1984)

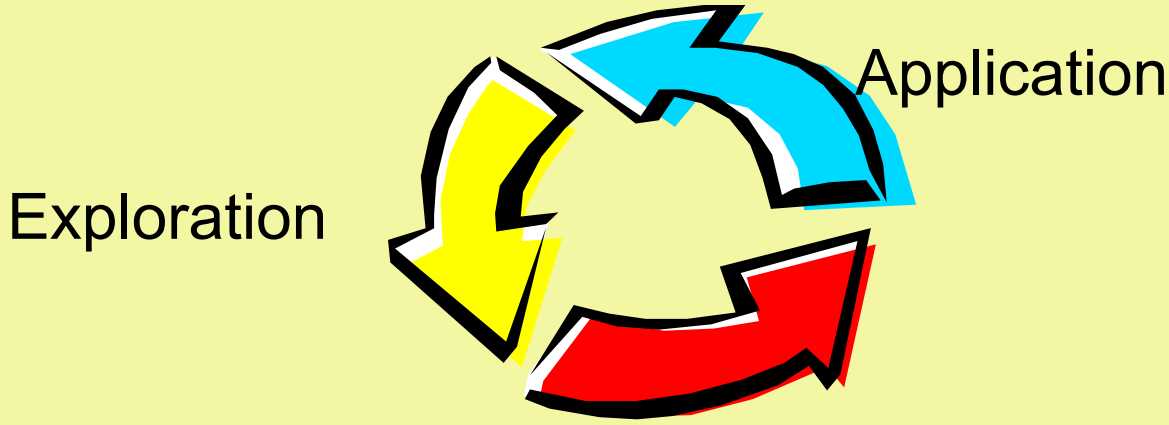
Critical Parts of Learning Cycle

- Exploration - new concepts should be introduced with minimum explanation and allow students to "construct" basic concepts



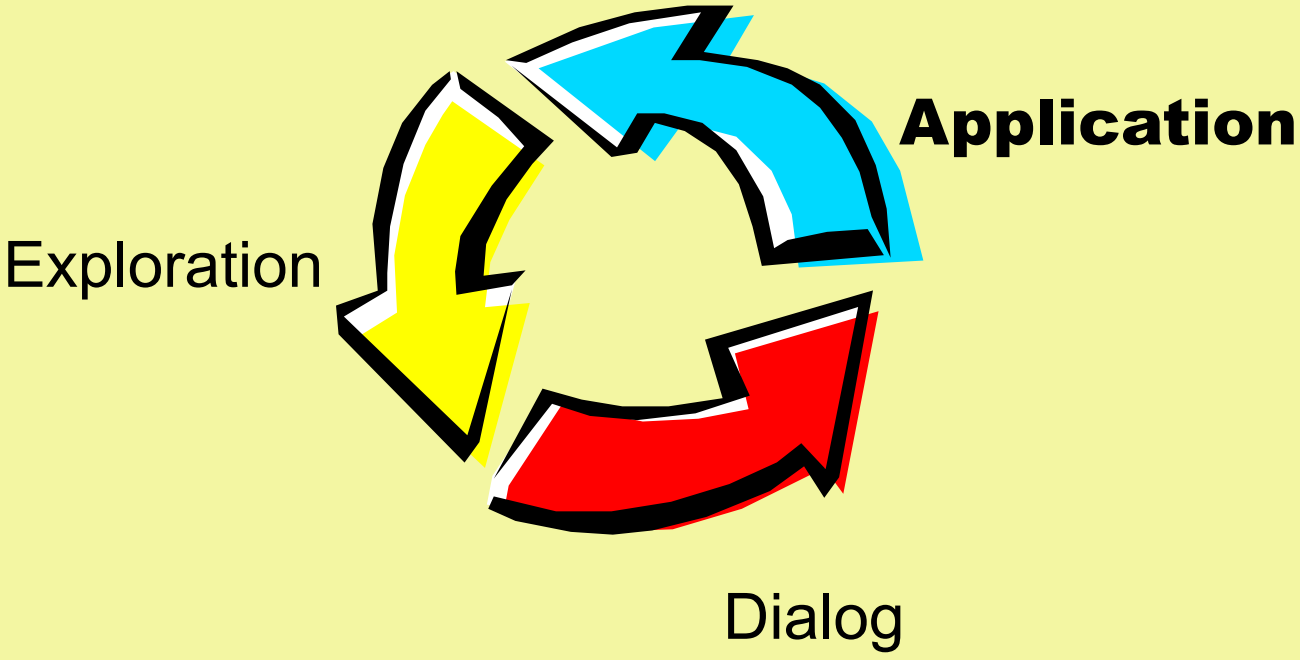
Critical Parts of Learning Cycle

•Dialog - present theory, standard terminology, and ideas in relation to what students have done in the exploration. The dialog can extend the basic concepts to the more complex leading to either an application or another exploration.



Critical Parts of Learning Cycle

- Application - This section of the cycle presents a problem typical of an industrial situation for the student to solve.

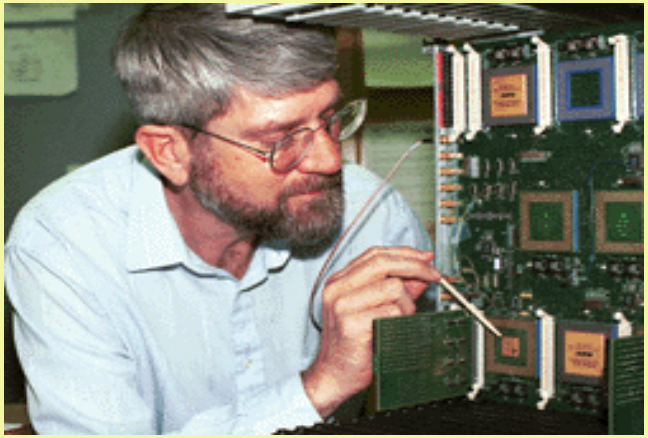


Examples of use

- Engineering Materials- Hardness unit starts with Mhos scale and classification and evolves to Rockwell scale.
- PLC Module - develops concept of N.O and N.C. switches and evolves to the XIC and XIO commands of PLC ladder logic.
- The exploration is the most difficult part of the module (for the instructor)!

Revised Existing Manufacturing Programs

- Add Nanofabrication to the Manufacturing Technology Options
- Options are now
  Automatic Controls
  Machining
  Welding Fabrication
  Nanofabrication



- All four share common General Education and Manufacturing Core of courses.

Manufacturing Core Courses

- EGR100Engineering Seminar 1
- SET105 Technical Computing 3
- MET106Geometric Dimensioning and Tolerancing1
- MET112Engineering Materials 4
- MET200Metrology 3
- EET103Introduction to Electronics3
- MIT107Electronic Fabrication 3
- 18 Credits Total

General Education Core

- ENG101English Composition 1 3
- ENG103Technical Communications 3
- MAT 114Math for the Technologies 1 4
- MAT116Math for the Technologies 2 4
- Social Science Elective 3
- Humanities Elective 3
- PHY113Technical Physics 1 3
- Total Credits 23

Nanofabrication Major

- PHY114Technical Physics 2 3
- CHM109Introduction to Chemistry 4
- MFT211Material Safety & Equipment3
- MFT212Basic Nanofabrication Processes3
- MFT213Thin Films in Nanofabrication3
- MFT214Lithography for Nanofabrication3
- MFT215Materials Modification 3
- MFT216Characterization and Packaging3
- Total Credits 25
- 66 Credits for the major

Penn State Nano Lab Courses

The FAB

PENNSTATE
Nanofabrication Facility

Nanofabrication Manufacturing Technology [NMT]

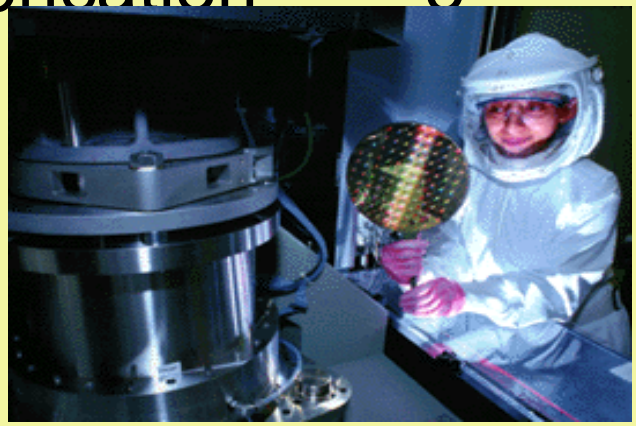
Nano Courses

- MFT211 Material Safety & Equipment 3
  Clean room Protocol
  Health Issues
  OSHA Safety Standards
  Certifications

- MFT212 Basic Nanofabrication Processes 3
- Top-down, Bottom-up and hybrid fabrication
  Basic Processing skills
  Vacuum Technology

Nano Courses

- MFT213 Thin Films in Nanofabrication 3
  Deposition Techniques
  Vapor Deposition
  Wet Chemical Etching
  Plasma Etching



- MFT214 Lithography for Nanofabrication 3 Pattern Transfer and Equipment
  Probe Techniques – ion and e-beam

Nano Courses

- MFT215 Materials Modification 3
Hands-on experience with Scanning Microscope
Equipment use for Slicing,
Etching, Polishing
and Epitaxial Growth

- MFT216 Characterization and Packaging 3
Encapsulation Techniques
Use of Atomic Force Microscope
Micro-fluidic Structures
Macro/ Micro-world Interfacing

Outreach Programs

- Coordinator to visit High Schools
- Workshops on Manufacturing and Technology

- Presentations to schools
- Presentations to Community Groups

Future Activities

Accreditation by the National Association of Industrial Technology

Area	Required	In CCAC Nanofabrication Program
Communications	**6-8**	**6**
Mathematics	**4-12**	**8**
Physical Sciences	**4-12**	**10**
Management or Technology	**36-42**	**36**
General Electives	**0-10**	**6**

Future Activities

Articulation to BS Degree in Nanofabrication Technology at California University of Pennsylvania

Make tie-in with new Biotechnology Major at CCAC

Develop new 2 Credit general interest course in Nanotechnology to be offered at CCAC

Begin Newsletter to send to schools with points of interest about Manufacturing and Nanotechnology

Other Careers @ CCAC

- Manufacturing Technology
  Nanofabrication, Controls, Machining, Welding
- Electronic Engineering Technology
- Microcomputer Electronics Technology
- Robotics & Automated Systems Technology
- Computer Aided Drafting & Design
  Technology

Other Careers @ CCAC

- Architectural Drafting & Design Technology
- Mechanical Drafting & Design Technology
- Science and Engineering Technology
- Civil Engineering Technology
- Engineering Science – Transfer Only

For additional information:

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