Atlas of Nanotechnology

Foothill DeAnza Colleges

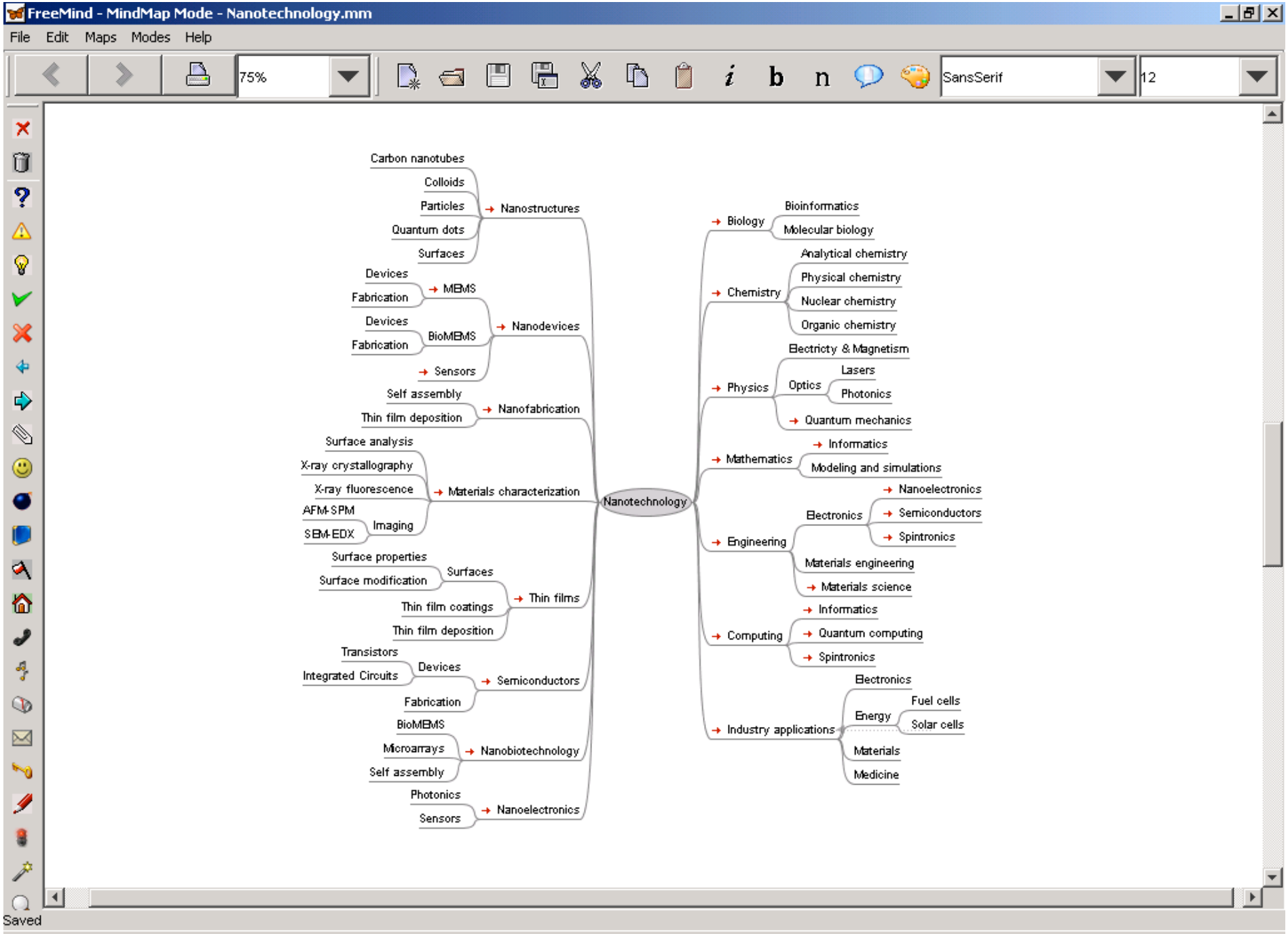
Nanotechnology Program

Atlas of Nanotechnology

- An ***Atlas of Nanoscience and Nanoskills***
- Six separate maps
  - Topic map of the domain (terms)
  - Knowledge map (what people know) = K
  - Skill map (what people do) = S
  - Industry map (companies and IP)
  - Course map of nanoscience (who teaches what)
  - Learning object map (SCORM and LOM)
- All six maps ***interlinked*** through ***K&S attributes***

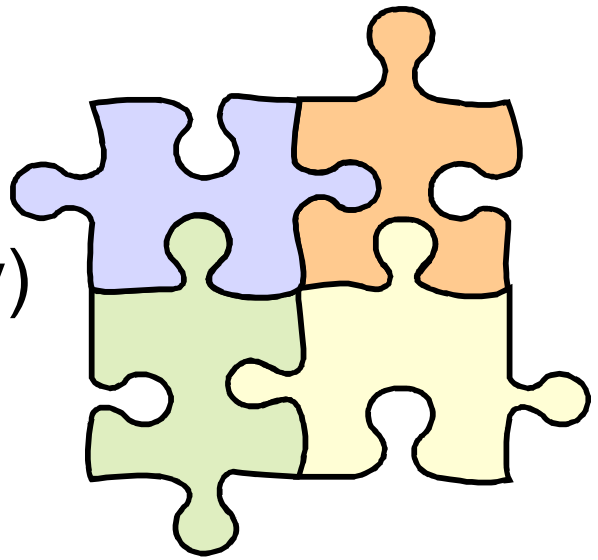
Nanoscience Topic Maps

- Topic maps are a ***'network of topics'*** that are ***interconnected*** in an ontology
- Nanoscience topic maps includes the ***top level subjects*** (physics chemistry, biology, materials science, electronics)
- And also include the ***'nano specific' terminology*** – self assembly, carbon nanotubes, molecular manufacturing

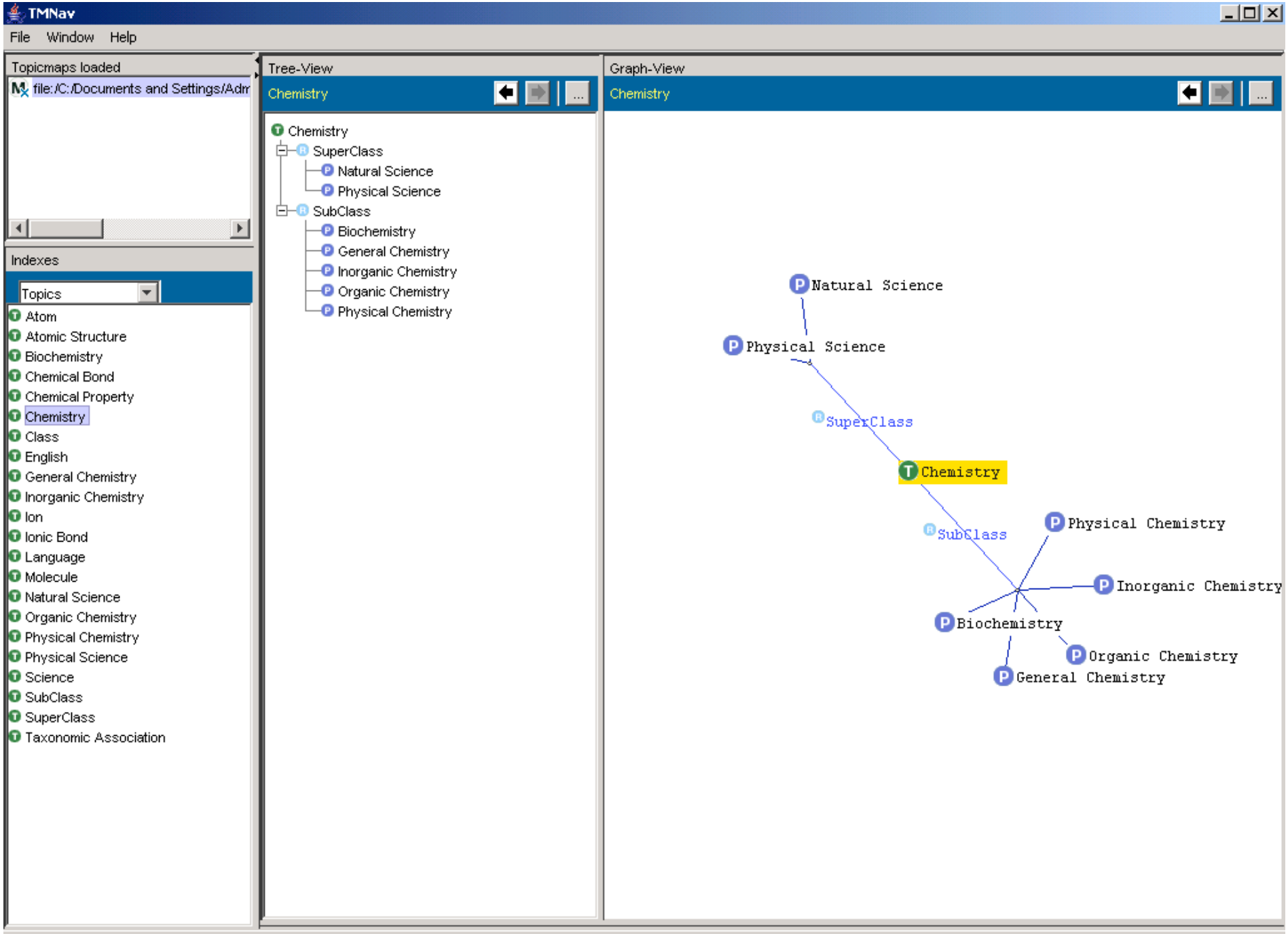

FreeMind - MindMap Mode - Nanotechnology.mm
File Edit Maps Modes Help
75%
SansSerif
12
Nanotechnology
Nanostructures
Carbon nanotubes
Colloids
Particles
Quantum dots
Surfaces
Nanodevices
MBMS
Devices
Fabrication
BioMBMS
Devices
Fabrication
Sensors
Nanofabrication
Self assembly
Thin film deposition
Materials characterization
Surface analysis
X-ray crystallography
X-ray fluorescence
Imaging
AFM-SPM
SBM-EDX
Thin films
Surfaces
Surface properties
Surface modification
Thin film coatings
Thin film deposition
Semiconductors
Devices
Transistors
Integrated Circuits
Fabrication
Nanobiotechnology
BioMBMS
Microarrays
Self assembly
Nanoelectronics
Photonics
Sensors
Biology
Bioinformatics
Molecular biology
Chemistry
Analytical chemistry
Physical chemistry
Nuclear chemistry
Organic chemistry
Physics
Electricty & Magnetism
Optics
Lasers
Photonics
Quantum mechanics
Mathematics
Informatics
Modeling and simulations
Engineering
Electronics
Nanoelectronics
Semiconductors
Spintronics
Materials engineering
Materials science
Computing
Informatics
Quantum computing
Spintronics
Industry applications
Electronics
Energy
Fuel cells
Solar cells
Materials
Medicine
Saved

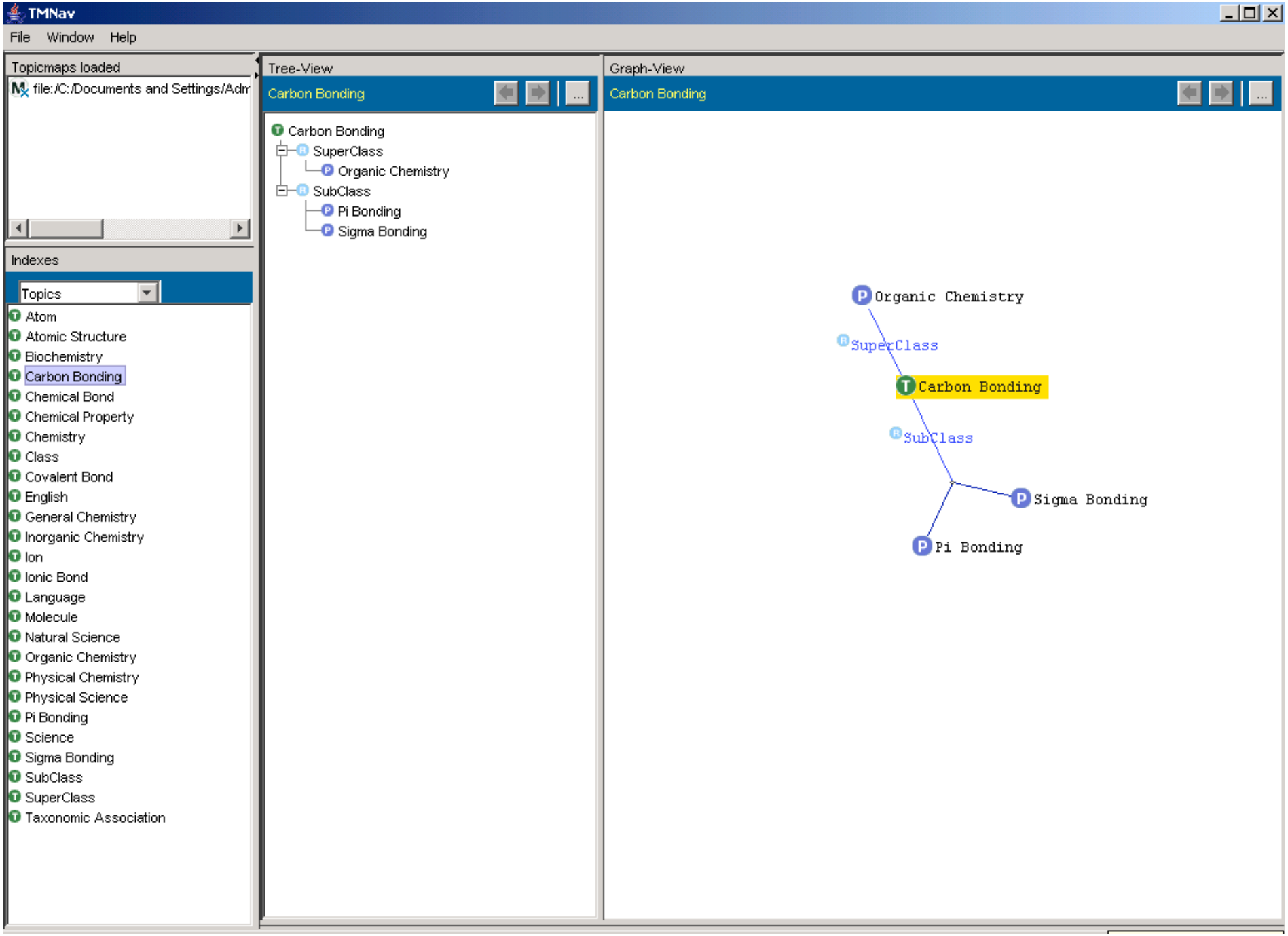
Connecting Topic Maps

- Nano terminology
  - Nano ontology (categories)
  - Nano taxonomy (terminology)
- Nano ‘work’ (skills)
- Nano courses (knowledge)
- Nano curriculum (course objects)
  - Courses contain K&S learning outcomes



*Topic maps will eventually link **work skills** with **learning outcomes***


TMNav
File
Window
Help
Topicmaps loaded
file:/C:/Documents and Settings/Adm
Indexes
Topics
Atom
Atomic Structure
Biochemistry
Chemical Bond
Chemical Property
Chemistry
Class
English
General Chemistry
Inorganic Chemistry
Ion
Ionic Bond
Language
Molecule
Natural Science
Organic Chemistry
Physical Chemistry
Physical Science
Science
SubClass
SuperClass
Taxonomic Association
Tree-View
Chemistry
Chemistry
SuperClass
Natural Science
Physical Science
SubClass
Biochemistry
General Chemistry
Inorganic Chemistry
Organic Chemistry
Physical Chemistry
Graph-View
Chemistry
Natural Science
Physical Science
SuperClass
Chemistry
SubClass
Physical Chemistry
Inorganic Chemistry
Biochemistry
Organic Chemistry
General Chemistry


TMNav
File
Window
Help
Topicmaps loaded
file:/C:/Documents and Settings/Adm
Indexes
Topics
Atom
Atomic Structure
Biochemistry
Carbon Bonding
Chemical Bond
Chemical Property
Chemistry
Class
Covalent Bond
English
General Chemistry
Inorganic Chemistry
Ion
Ionic Bond
Language
Molecule
Natural Science
Organic Chemistry
Physical Chemistry
Physical Science
Pi Bonding
Science
Sigma Bonding
SubClass
SuperClass
Taxonomic Association
Tree-View
Carbon Bonding
Carbon Bonding
SuperClass
Organic Chemistry
SubClass
Pi Bonding
Sigma Bonding
Graph-View
Carbon Bonding
Organic Chemistry
SuperClass
Carbon Bonding
SubClass
Sigma Bonding
Pi Bonding

What Problems Are We Solving?

- Pathways for intelligent workforce development
- Pathways for formal nanotech education
- Are two courses similar?
- Recognizing ‘aggregated learning outcomes’ from disparate institutions

Knowledge Map

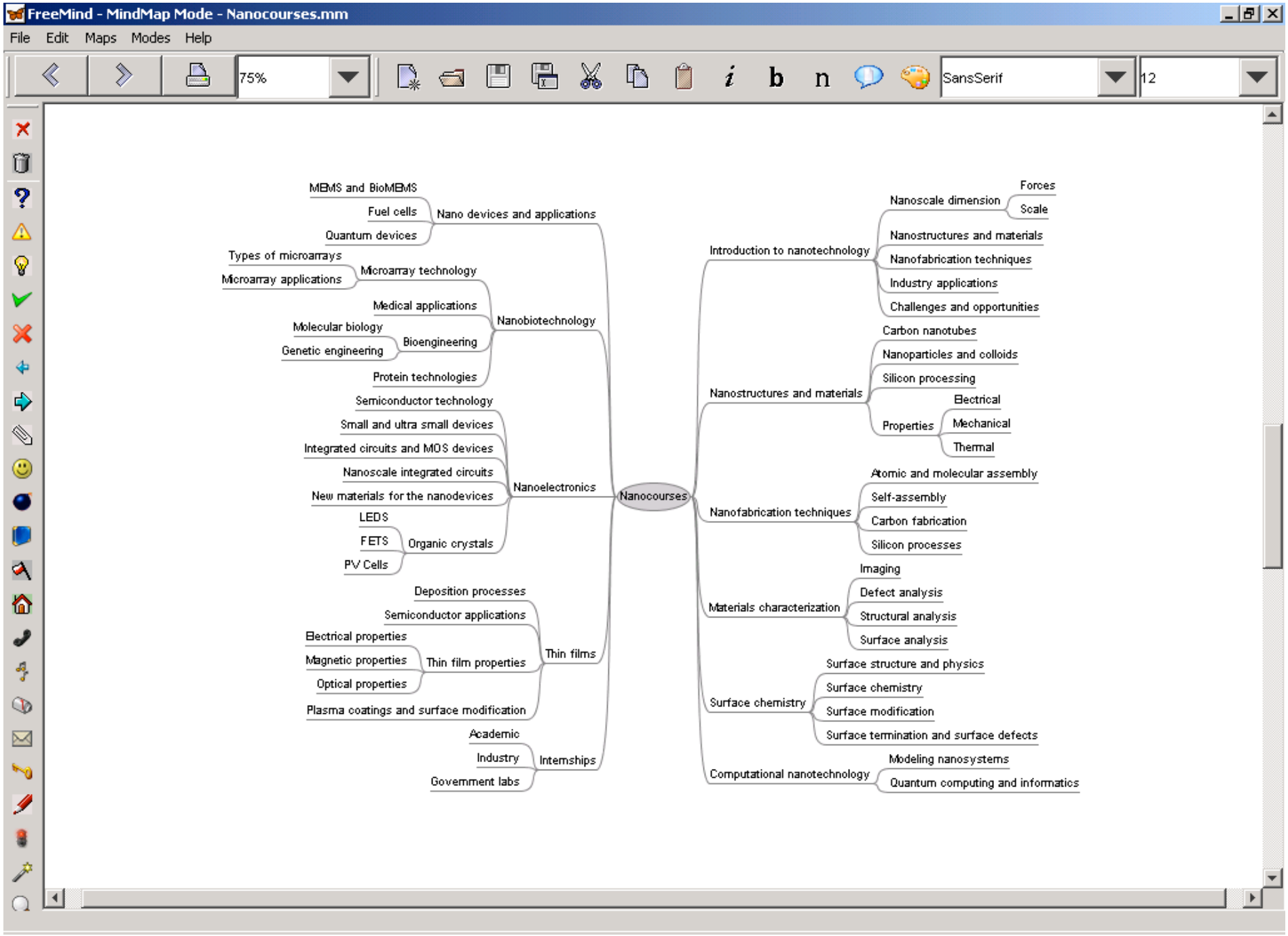
- What are the ***key concepts*** that students and working professionals need to know?
- These are both ***prerequisites*** to learning new concepts in nanoscience, as well as ***key learning outcomes*** from coursework
- Knowledge map is connected to ‘courses’ through the ***knowledge attribute*** in KSA

Skill Map

- What ***skills*** are needed to do ***work*** in nanoscience? What ***tasks*** are practiced in the course of ‘doing’ nanotechnology?
- Skill map is derived from ***interviews*** with industry and nanoscience workers
- Skill map is connected to ***‘courses’*** map through the ***skill attribute*** of KSA schema

Course Map

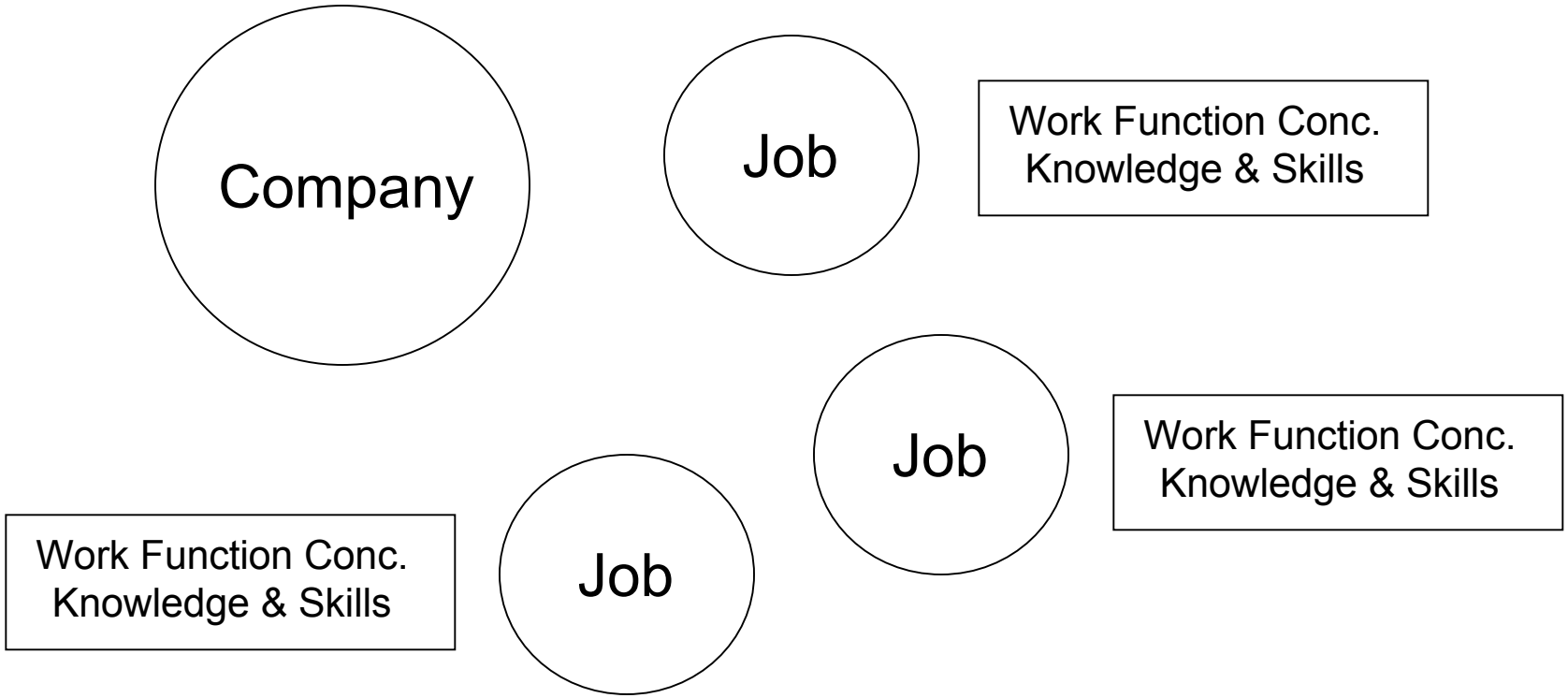
- Course map is a **comprehensive list of courses** (starting in CA Bay Area), their descriptions and ***KSA learning outcomes***
- They appear in engineering, physics, chemistry, materials science, electronics
- Each course has a knowledge and skill (KSA) attribute for ***each*** learning outcome


FreeMind - MindMap Mode - Nanocourses.mm
File
Edit
Maps
Modes
Help
75%
SansSerif
12
Nanocourses
Nano devices and applications
MEMS and BioMEMS
Fuel cells
Quantum devices
Nanobiotechnology
Microarray technology
Types of microarrays
Microarray applications
Bioengineering
Medical applications
Molecular biology
Genetic engineering
Protein technologies
Nanoelectronics
Semiconductor technology
Small and ultra small devices
Integrated circuits and MOS devices
Nanoscale integrated circuits
New materials for the nanodevices
Organic crystals
LEDS
FETS
PV Cells
Thin films
Deposition processes
Semiconductor applications
Thin film properties
Electrical properties
Magnetic properties
Optical properties
Plasma coatings and surface modification
Internships
Academic
Industry
Government labs
Introduction to nanotechnology
Nanoscale dimension
Forces
Scale
Nanostructures and materials
Nanofabrication techniques
Industry applications
Challenges and opportunities
Nanostructures and materials
Carbon nanotubes
Nanoparticles and colloids
Silicon processing
Properties
Electrical
Mechanical
Thermal
Nanofabrication techniques
Atomic and molecular assembly
Self-assembly
Carbon fabrication
Silicon processes
Materials characterization
Imaging
Defect analysis
Structural analysis
Surface analysis
Surface chemistry
Surface structure and physics
Surface chemistry
Surface modification
Surface termination and surface defects
Computational nanotechnology
Modeling nanosystems
Quantum computing and informatics

Industry Map

- Companies and what they do
  - Core technology / IP
- Names of key individuals in the company
- Job positions (and typical positions)
  - Links from jobs to knowledge and skills
  - What K&S is required for nanoskilled work?
- Products manufactured or in R&D
  - Links into the future nanodevices topic map

Industry Map

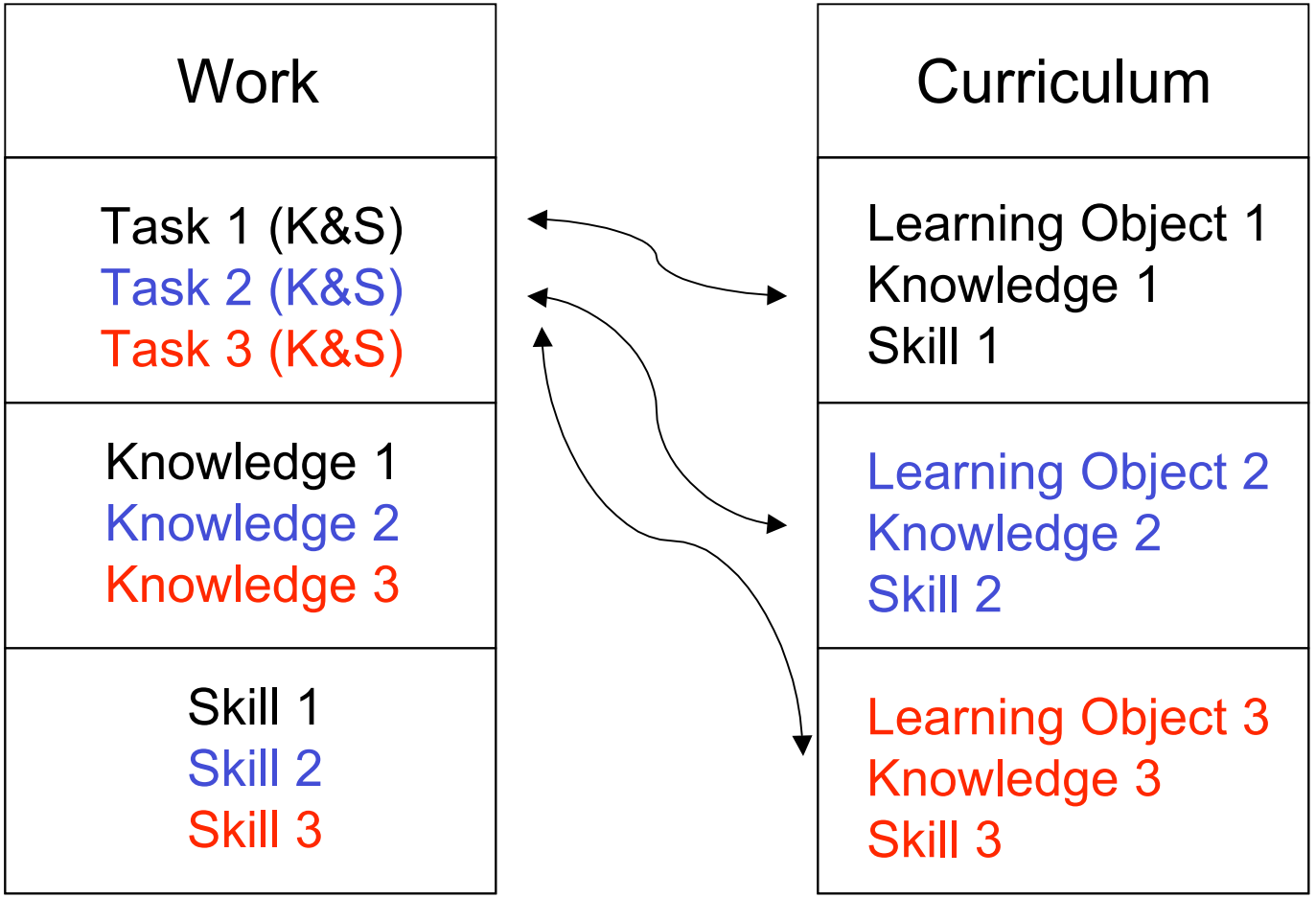


Companies have Workers who do Work and need Knowledge and Skills

Putting it All Together

- Job objects are divided into critical work functions (WF) a series of discrete tasks
- Each task has a requisite knowledge and skill (K&S) requirement (typically education and experience on a resume)
- Career certificates should have courses with ***K&S learning outcomes*** that map into the critical WF's needed in industry

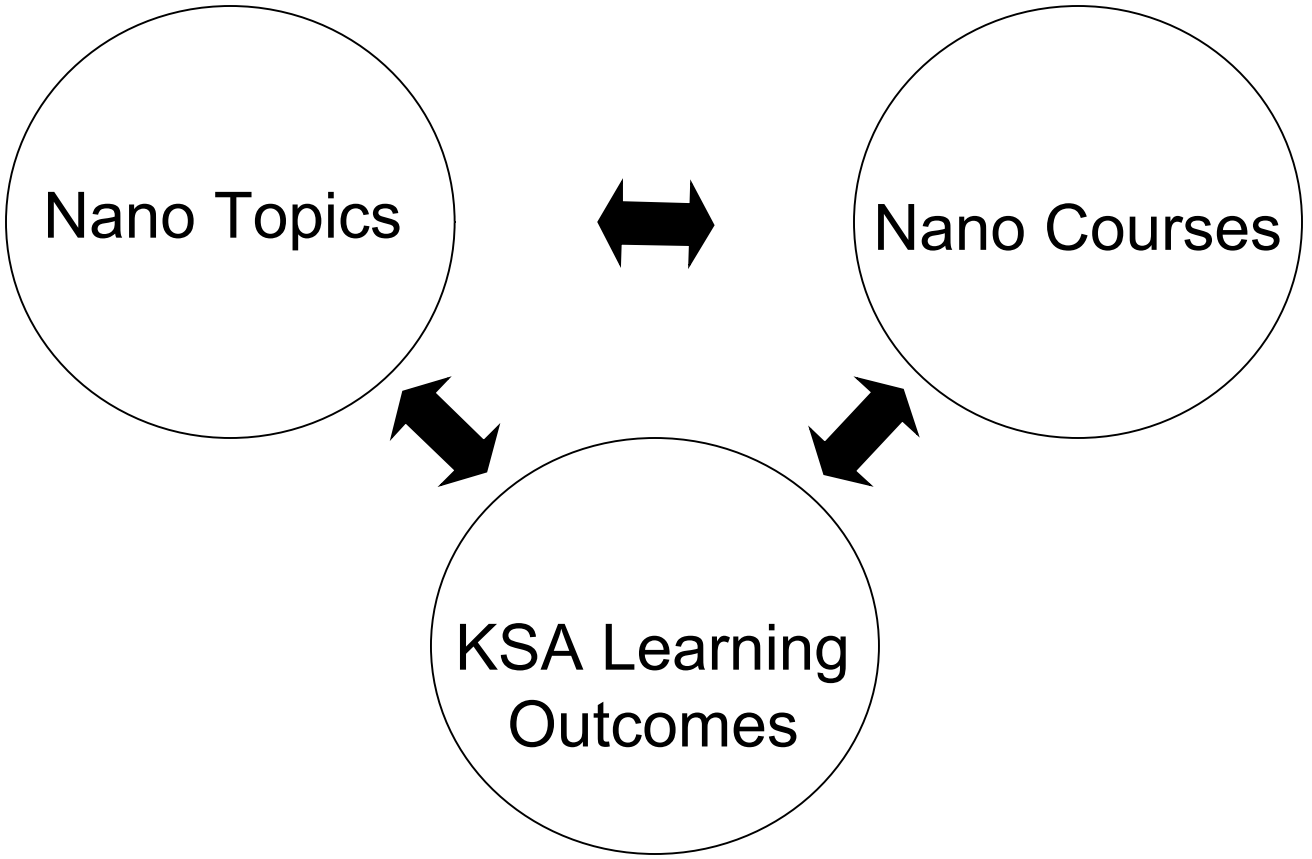
Mapping Work Skills to KSA Learning Outcomes



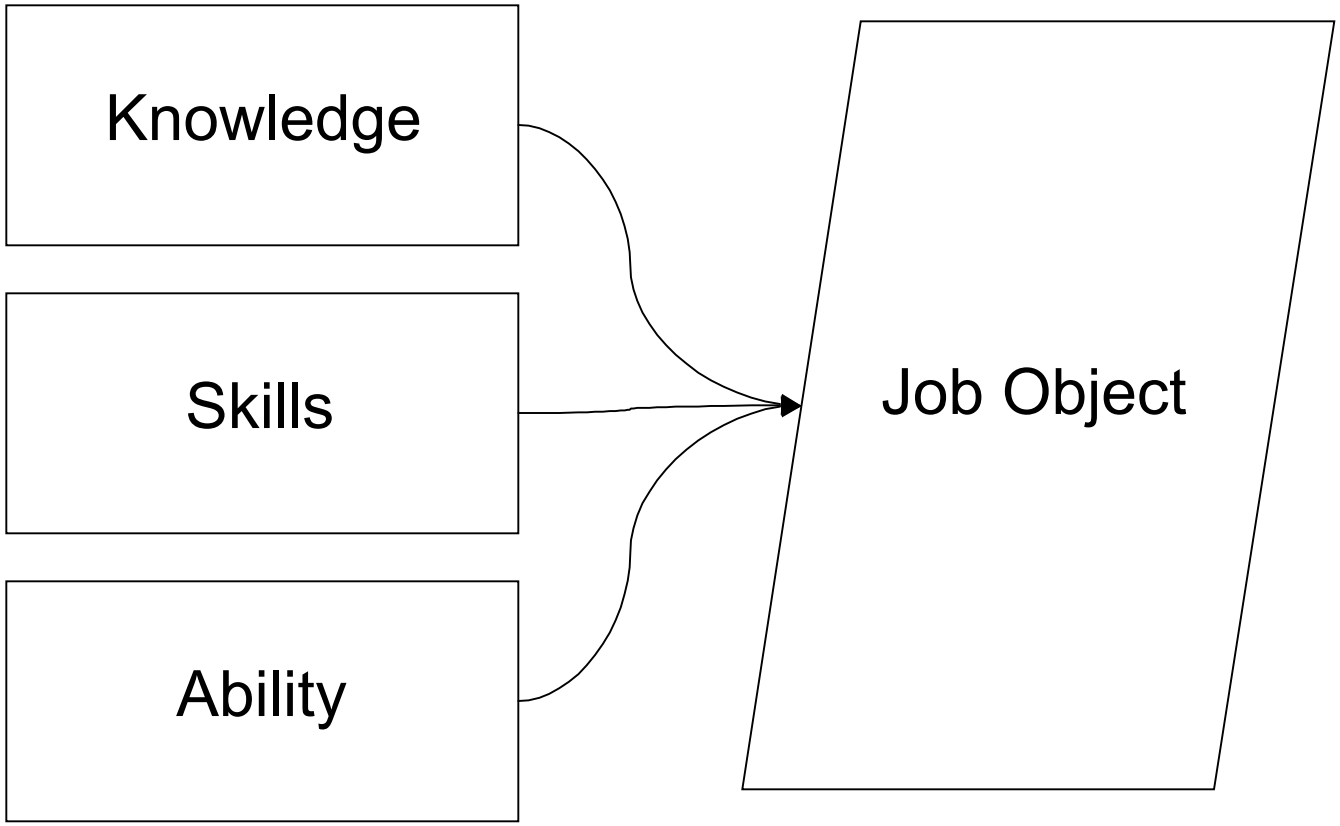
Understanding Nanoskills

- Map of companies and competencies
- Include map of job title and work function
  - What ***'work'*** do people do? (WF)
  - What ***knowledge*** (K) do they need?
  - What ***skills*** (S) do they need?
- Link K and S from above to either LOs from course objects, or learning objects
- ***Remedial*** learning and / or ***fast skilling***

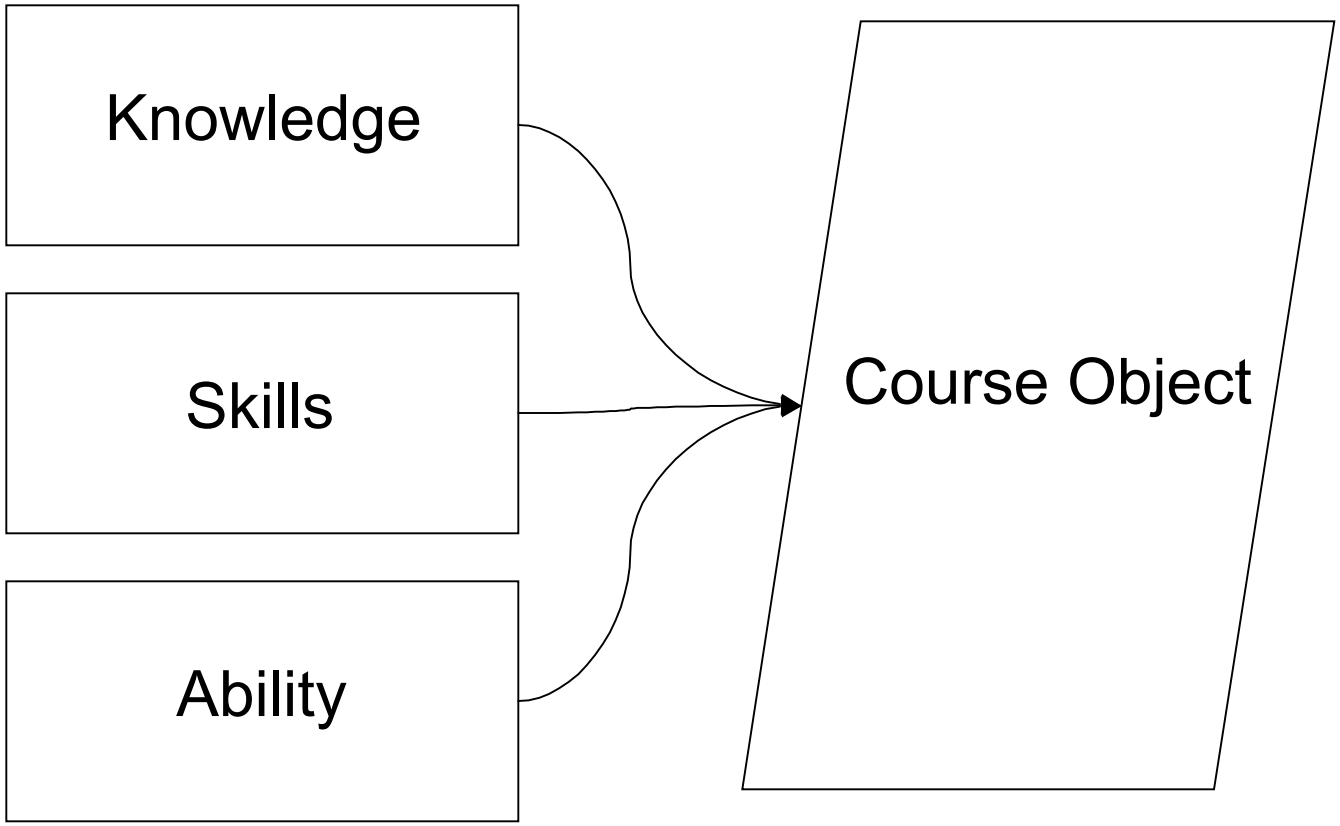
Linking XML Topic Maps



KSA From Job Objects



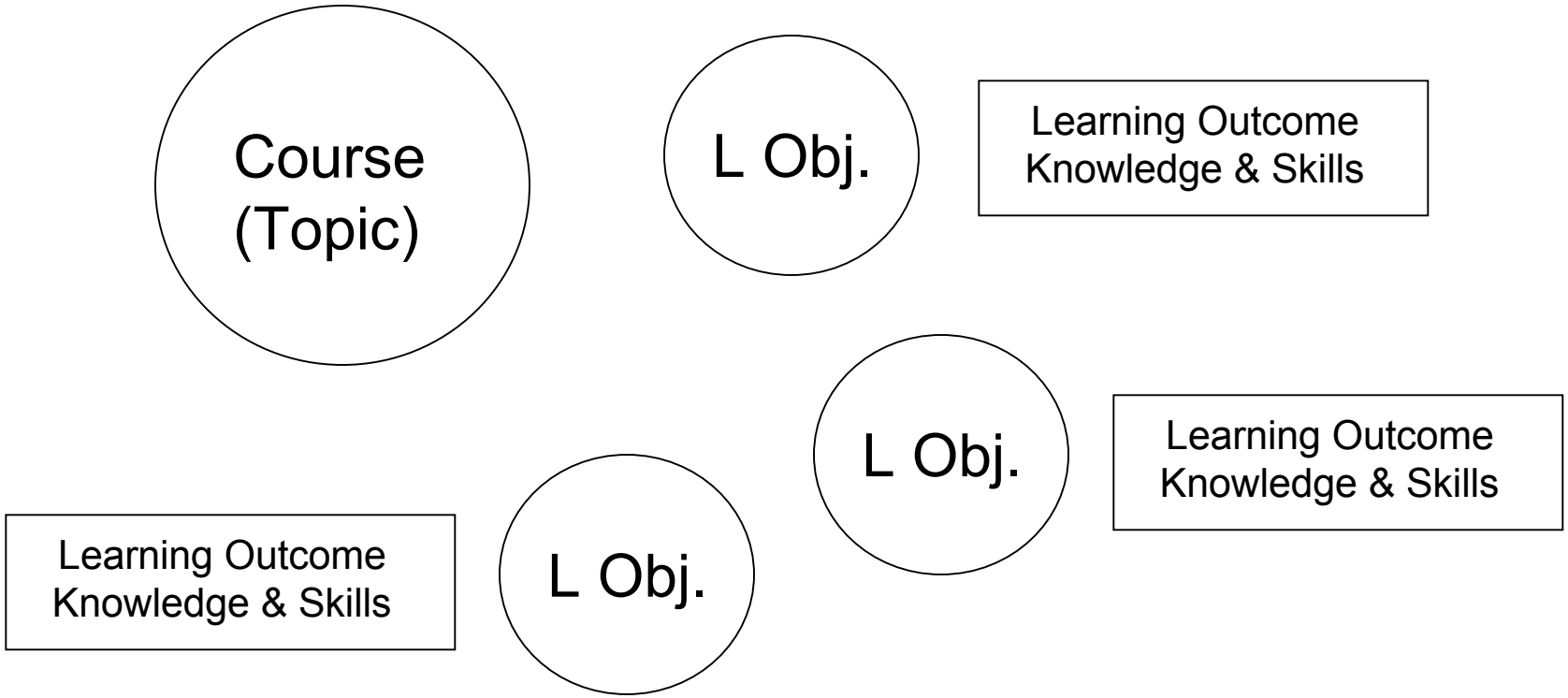
KSA From Course Objects



Learning Object Map

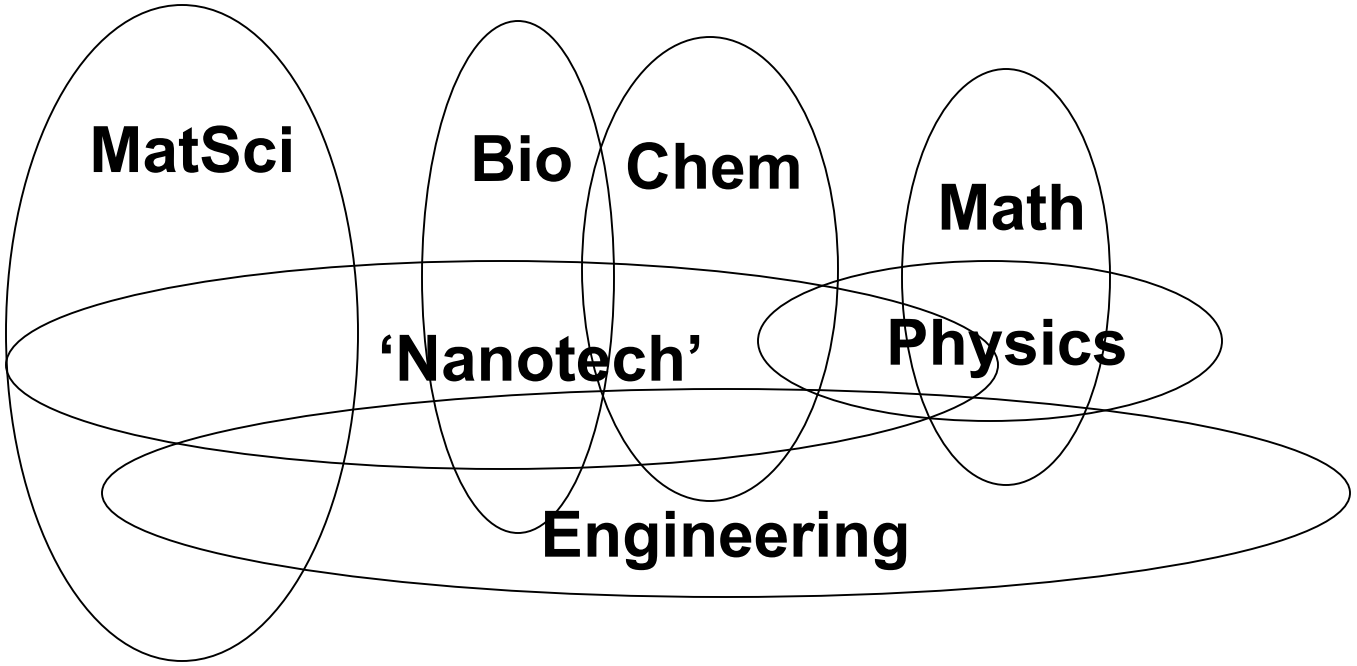
- Map of free standing learning objects
- Eventually will be ‘Web deployed’
  - SCORM standards / LOM (KSA) schema
- Each ‘object’ will have three attributes
  - Knowledge
  - Skills
  - Assessment
- Navigate a learning-space for a K&S

Learning Object Map



Companies have Workers who do Work with ***specific*** Knowledge and Skills

Curriculum Course Map



Concept by Ted Kahn

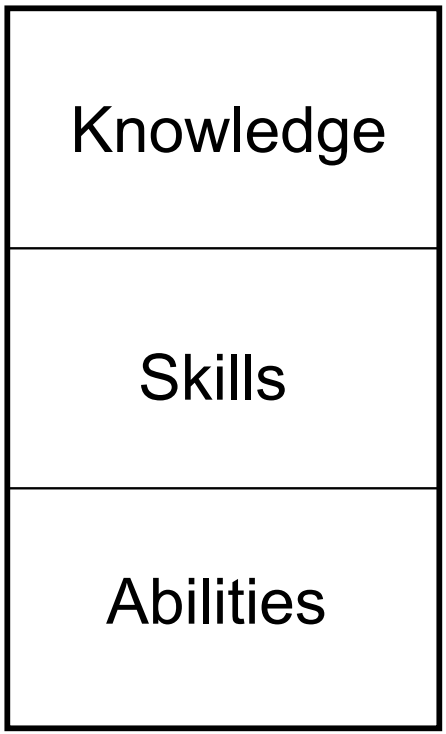
Nanotechnology ***emerges*** *from* ***new associations*** *of* ***nanoscale phenomena*** *in the core* ***subject areas***

Are Two Courses 'Similar'?

- Thin Film Processes
  - MatSci department
- Solid State Physics
  - Physics department
- Colloids and Surfaces
  - MatSci department
- Organic Chemistry
  - Chemical engineering
- Intro to Semiconductors
  - Electrical engineering
- Intro to Thin Films
  - Engineering
- Physics of Solids
  - MatSci department
- Surface Chemistry
  - Chemistry
- Organic Materials
  - MatSci department
- Semiconductor Materials
  - MatSci department

There are over 500 nano-related courses within 50 miles of FHDA

Learning Outcomes as Interchangeable Parts

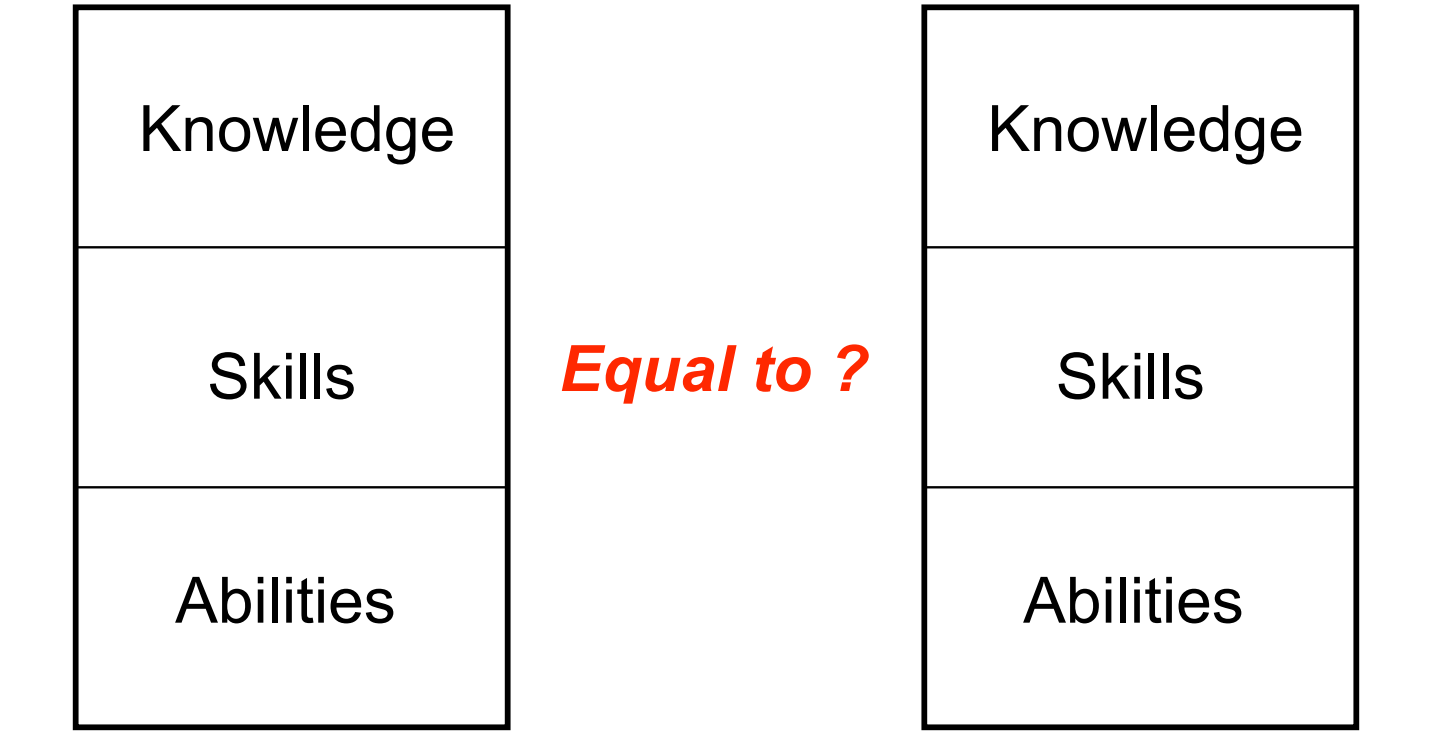


Declarative component of learning

Procedural component of learning

Cognitive or 'deep learning'

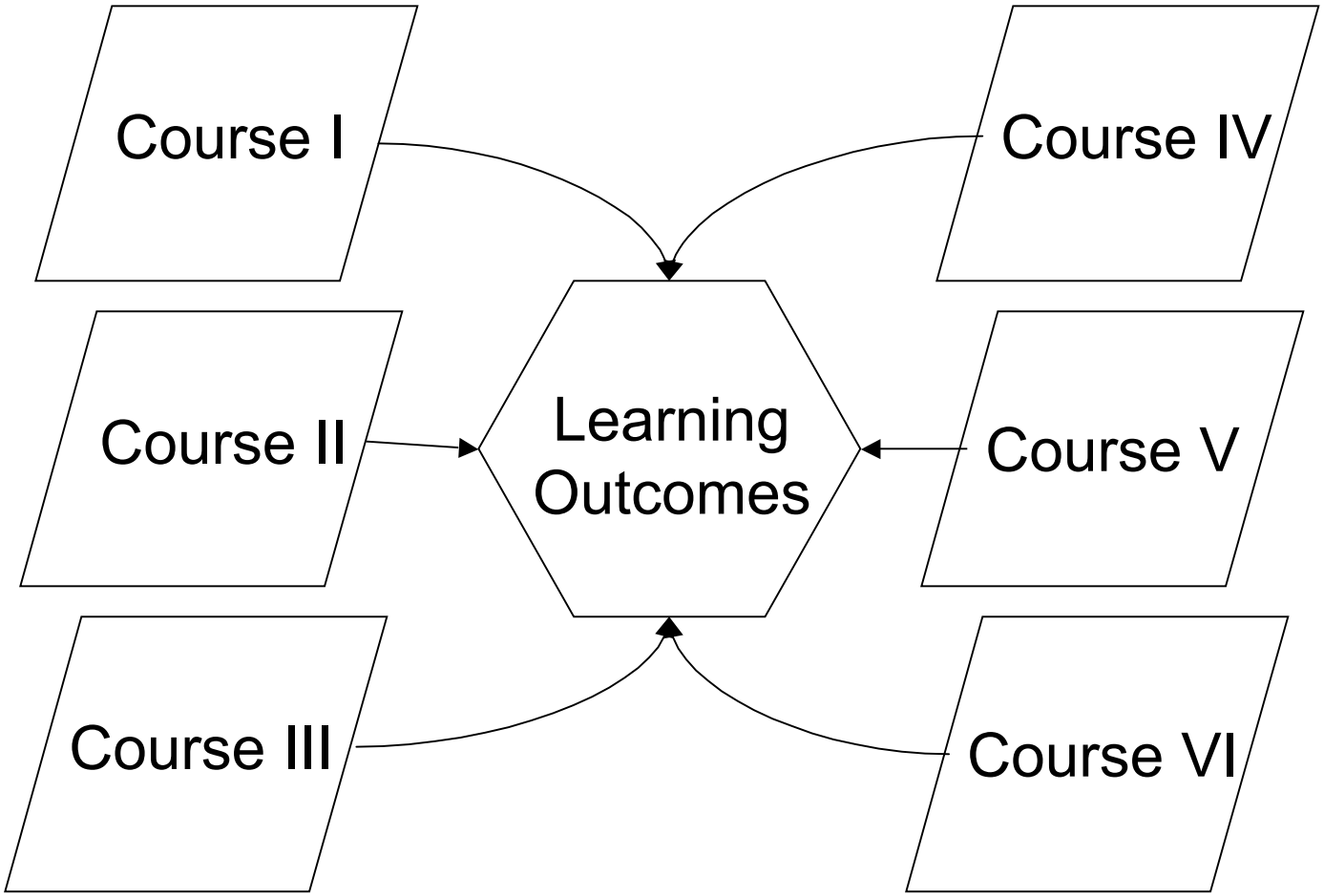
Course Objects as Interchangeable Parts



Learning Outcome(s)
Course A

Learning Outcome(s)
Course B

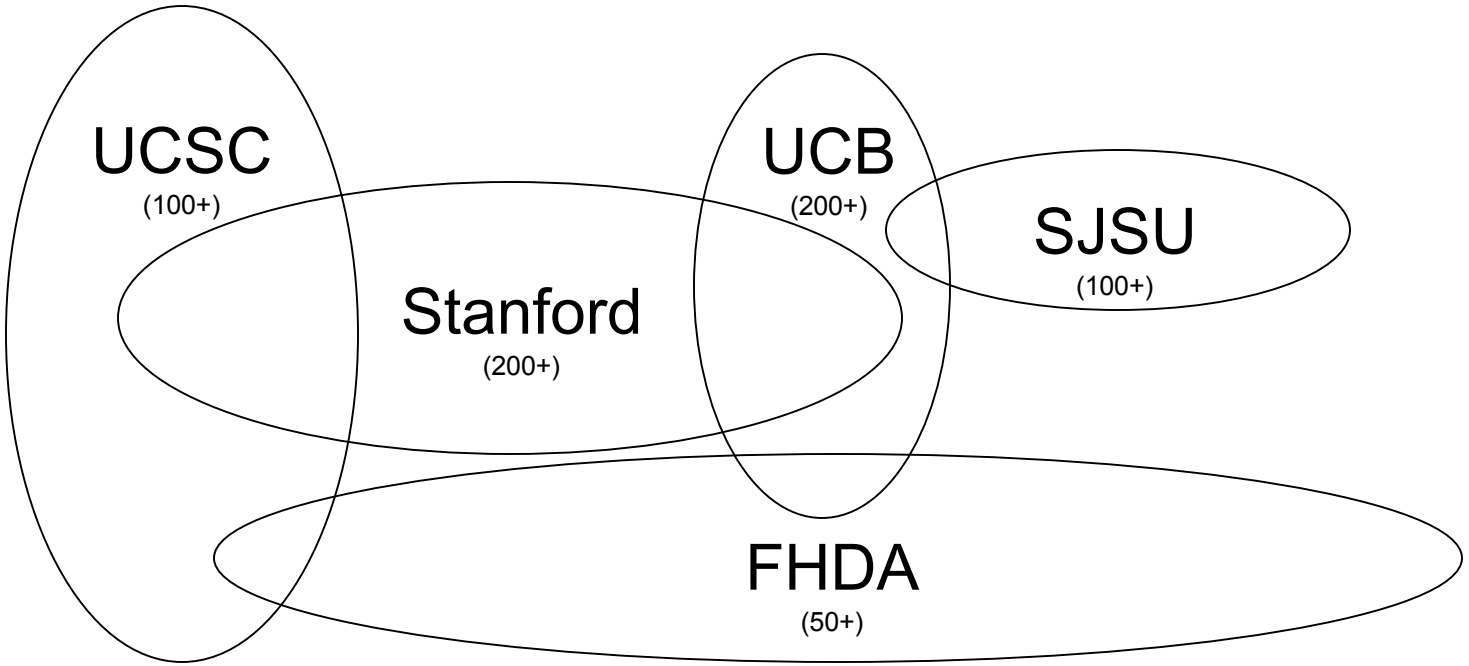
Aggregated Learning Outcomes



Logical Certificates

- Concept map nano outcomes
  - Materials, nano-bio, nano-opto, etc.
- Map (KSA) nano topics to classes
  - Locate courses that ***teach nano topics***
- Map (organize) classes into outcomes
  - ***Self-assemble*** logical certificate tracks
- Nano-***certificate*** = nano-topic ***roadmap***

Logical Certificate Map



*It is **probable**, not just **possible**, that we are **already** teaching the **principles of nanotechnology**, but we haven't **organized it!***

Timeline / Resources

- Atlas of Nanotech being built by FHDA team in conjunction with NASA / SRI
- Draft Atlas to be shown at SRI / NASA workshop at the end of March 2005
- Topic map will need a ***grant*** to expand beyond 2,000 terms and full data model
- XML topic map started in Summer 2005
- ***NSF proposal*** for funding in Fall 2005