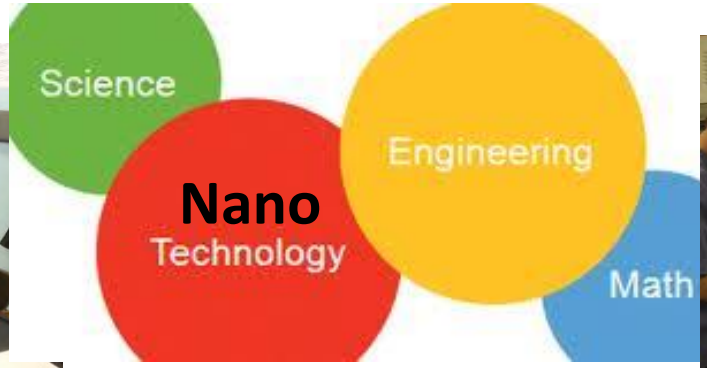
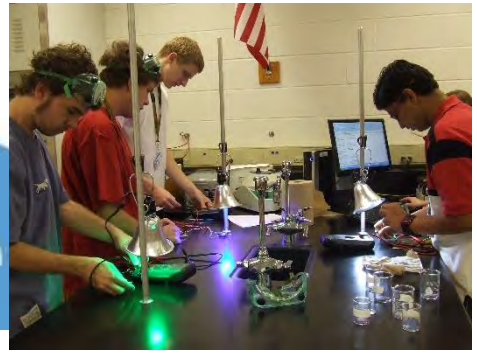
Using Interactive Materials World Modules to Teach Nanotechnology



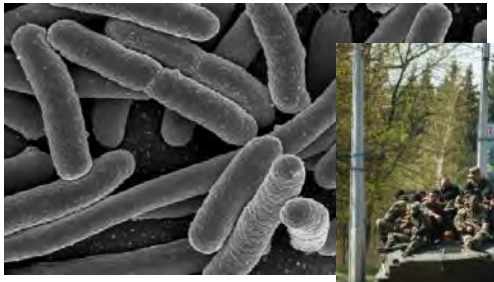
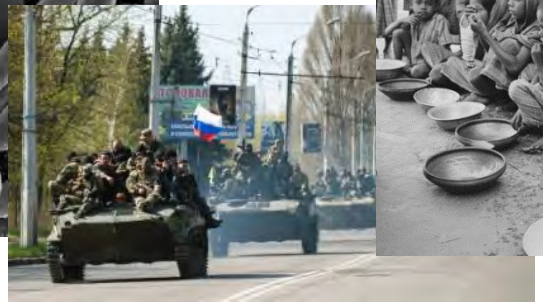


Critical Global Challenges

Top 10 global issues facing the 21th century

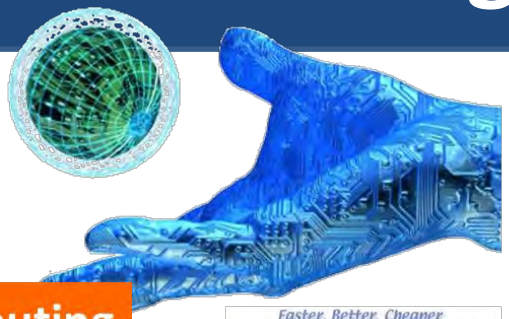




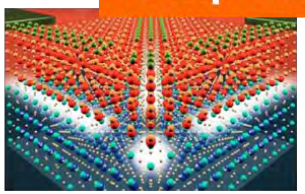





Potential Impact of Nanotechnology

- We need nanotechnology
  - It will raise our standard of living
  - Make our lives more secure
  - Improve healthcare delivery
  - Optimize our use of limited resources



Computing



Quantum computing with nanoelectronics

Transport

Resources

The future energy source

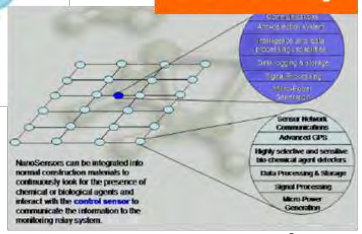
Clean Water

Nano water filtration

Healthcare

The future in Nanomedicine

Security



Nano sensor network

Nanotechnology for Energy

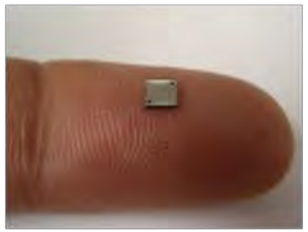
Improved efficiency in:

- Energy conversion
  - Improve ability to convert sunlight into electricity
  - Efficiently convert crude oil into various petroleum products
- Energy storage
  - Store energy efficiently so that we can use it whenever we need it
  - Create better batteries, fuel cells, and nanogenerators
- Energy transmission
  - Since energy is generated locally, electricity need to be transmitted with very little energy loss
- Energy use
  - Make products that use energy efficiently to conserve indirectly conserve large amounts of fossil fuels

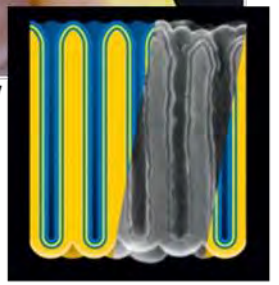
Solar cells using Nanotechnology

Turning crude oil into diesel fuel

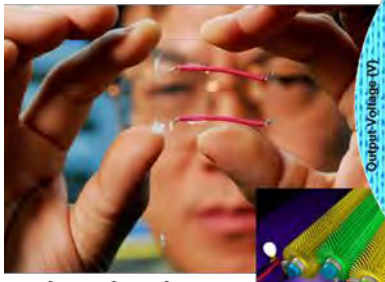
A sheet of nano battery



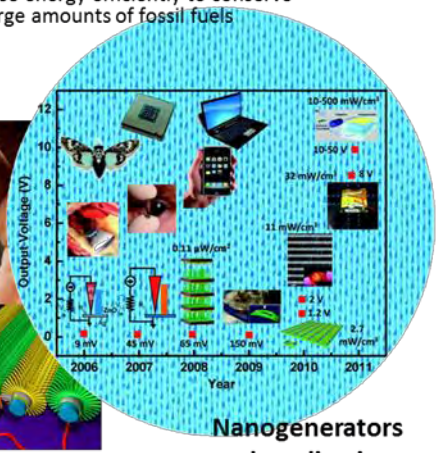
Nano fuel cell



CNT-based energy storage



Piezoelectric Nanogenerator

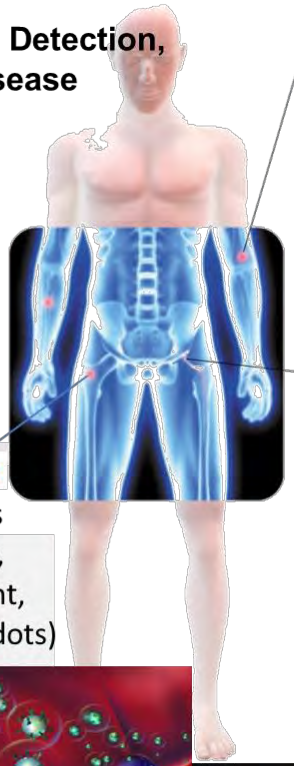


Nanogenerators and applications

NT for Medicine & Diagnostics

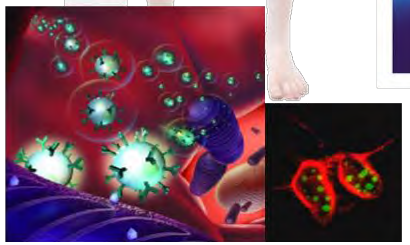
Futuristic Improvements in the Detection, Diagnosis and Treatment of disease

- Disease diagnosis and even therapy
- Quicker, more sensitive and more flexible tags or labels
- Drug delivery with high specificity
- Repair tissues and regenerate organs



1 GOAL: Improved Imaging

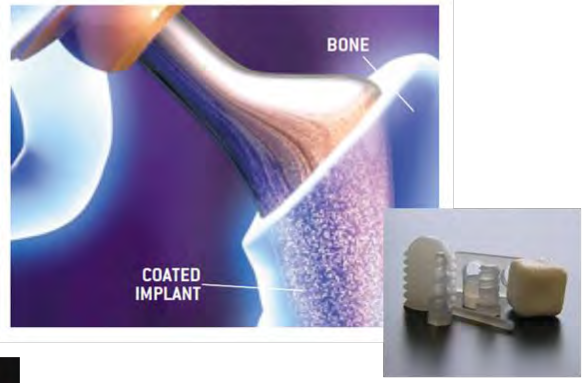
Improved or new contrast agents would detect problems at earlier, more treatable stages. They might, for instance, reveal tumors (red dots) only a few cells in size.



Antibody-labeled quantum dots traveled through the bloodstream to tumors in mice. The antibody then binds with proteins found on the surface of the tumor.

2 GOAL: New Ways to Treat Disease

3 GOAL: Superior Implants



Nanostructured calcium phosphate technology mimics "bioactivity" native bone crystals for bone-based orthopedic implants.

NT for the Environment

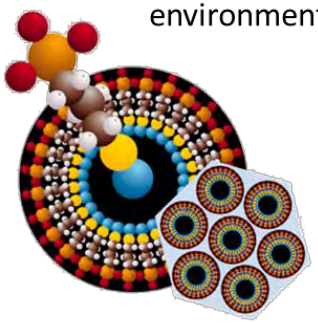
- Desalination
  - Develop smart membranes that remove salt from seawater with antimicrobial surfaces
- Personal water treatment
  - Create devices that can purify water at the tap, well, in their residences, or at the point of use.
- Pollution cleanup
  - Efficiently and safely remove environmental toxins

Clean water for safe drinking at point of use

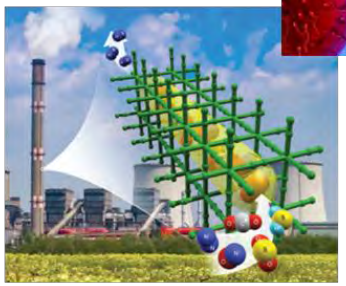
Nanotech in a straw-shaped water filter

Removal of arsenic with nanorust

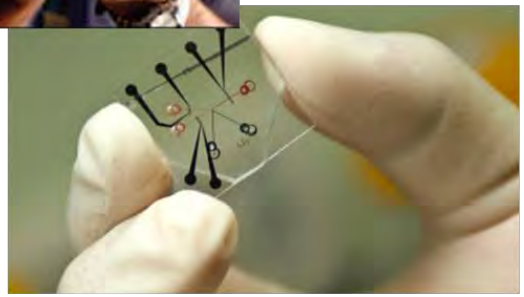
Desalination of sea water



Nanoporous sorbents for removing mercury



Trapping CO_2 emission using Nanocages



Portable desalination device

What Can We Do?

Society needs STEM-literate citizens who can understand, support, and adopt new technologies, so that we can solve global challenges in energy, health, environment, and communication!



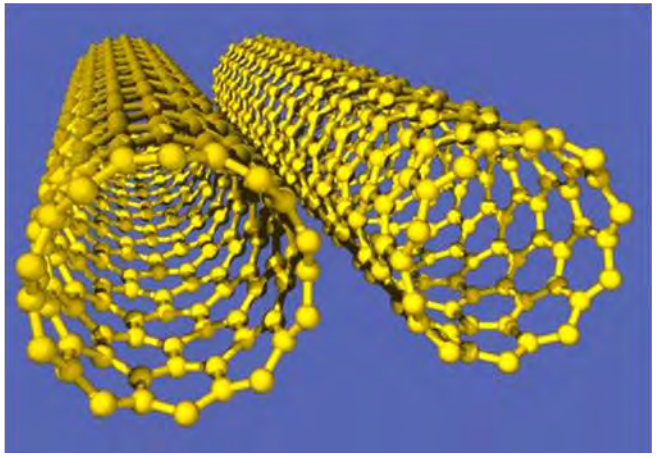

STEM Curriculum Needs

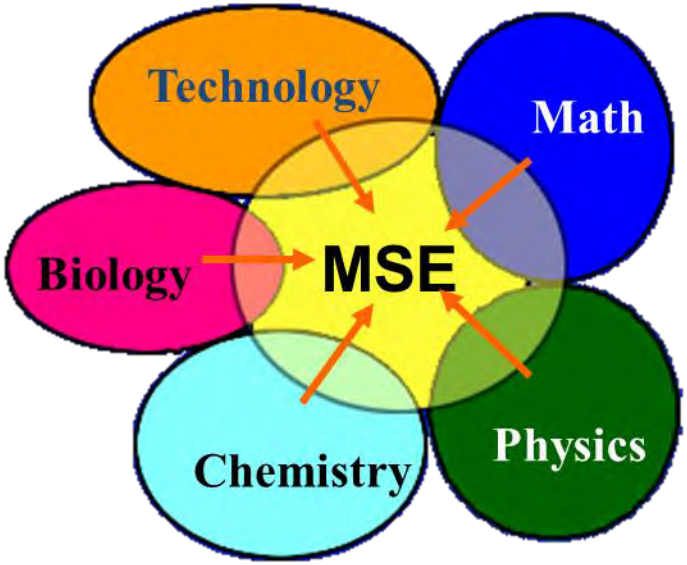
Universities/Companies want students/workers who

- Know STEM concepts and skills
- Can work collaboratively and communicate clearly
- Can think critically and creatively
- Can use digital media and technology fluently

MWM's Strategy

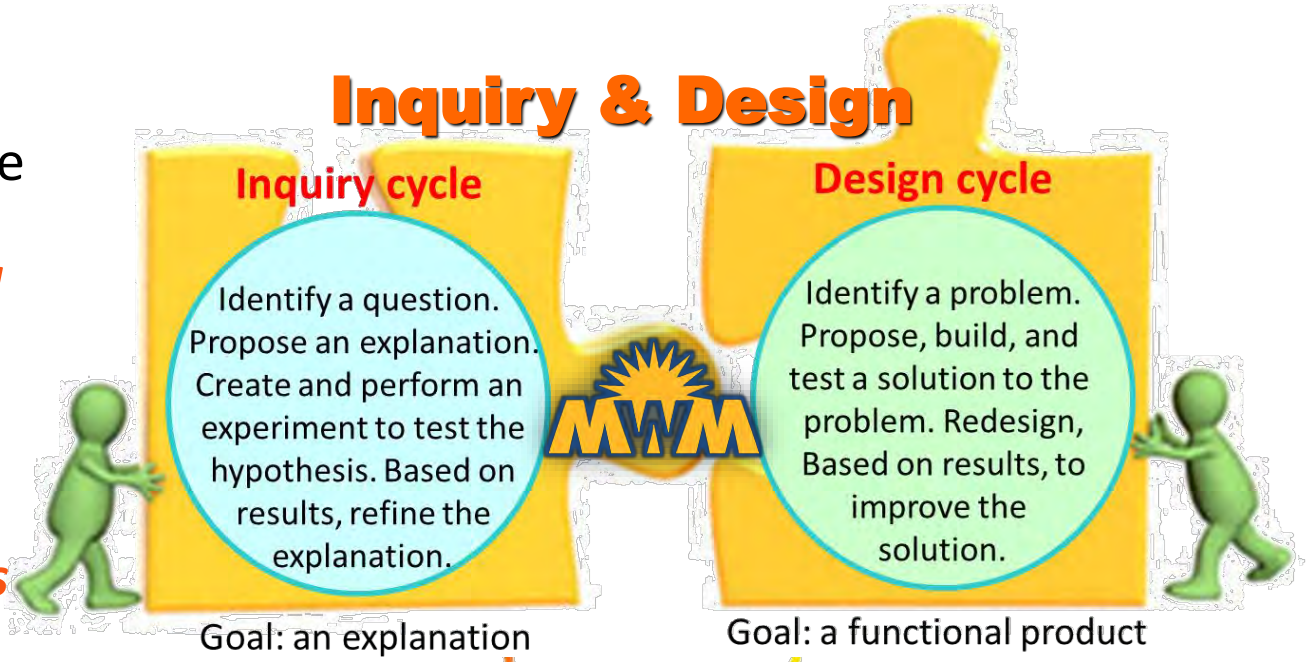
- ***Materials World Modules (MWM)*** is a groundbreaking STEM program launched in 1993 by Northwestern University with funding from the National Science Foundation
- The critical question that we asked ourselves: ***How can we link STEM to real life?***
- MWM's answer: ***Materials!***

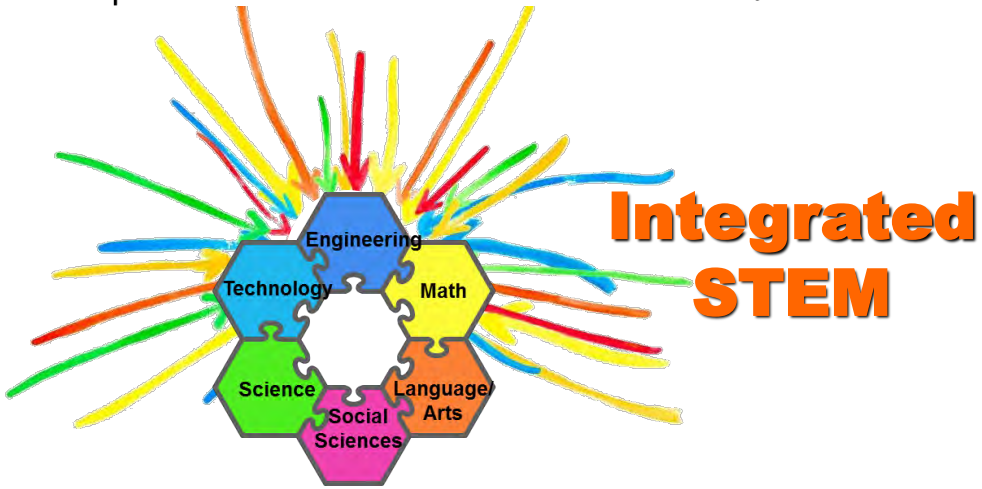




MWM's Model: Integrated Learning

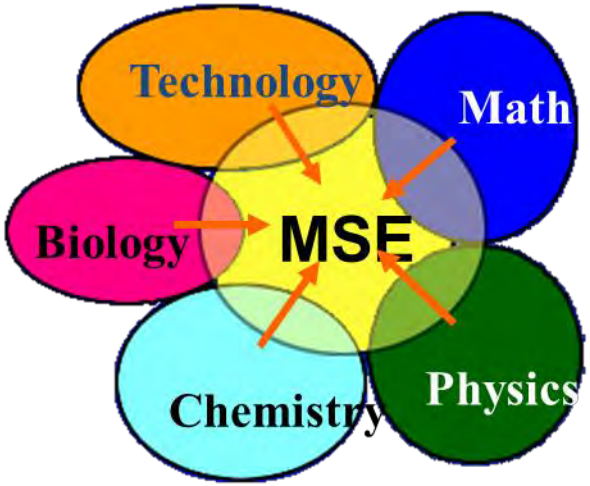
- Students complete a series of hands-on, ***inquiry-based*** activities
- Each module culminates in ***design challenges***
- Students simulate the work of ***scientists*** *(through activities that foster inquiry)* and ***engineers*** *(through design)*



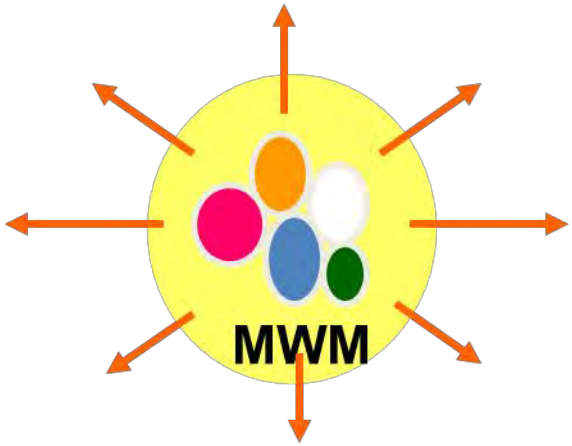


Cross-cutting Concepts via Materials & NT

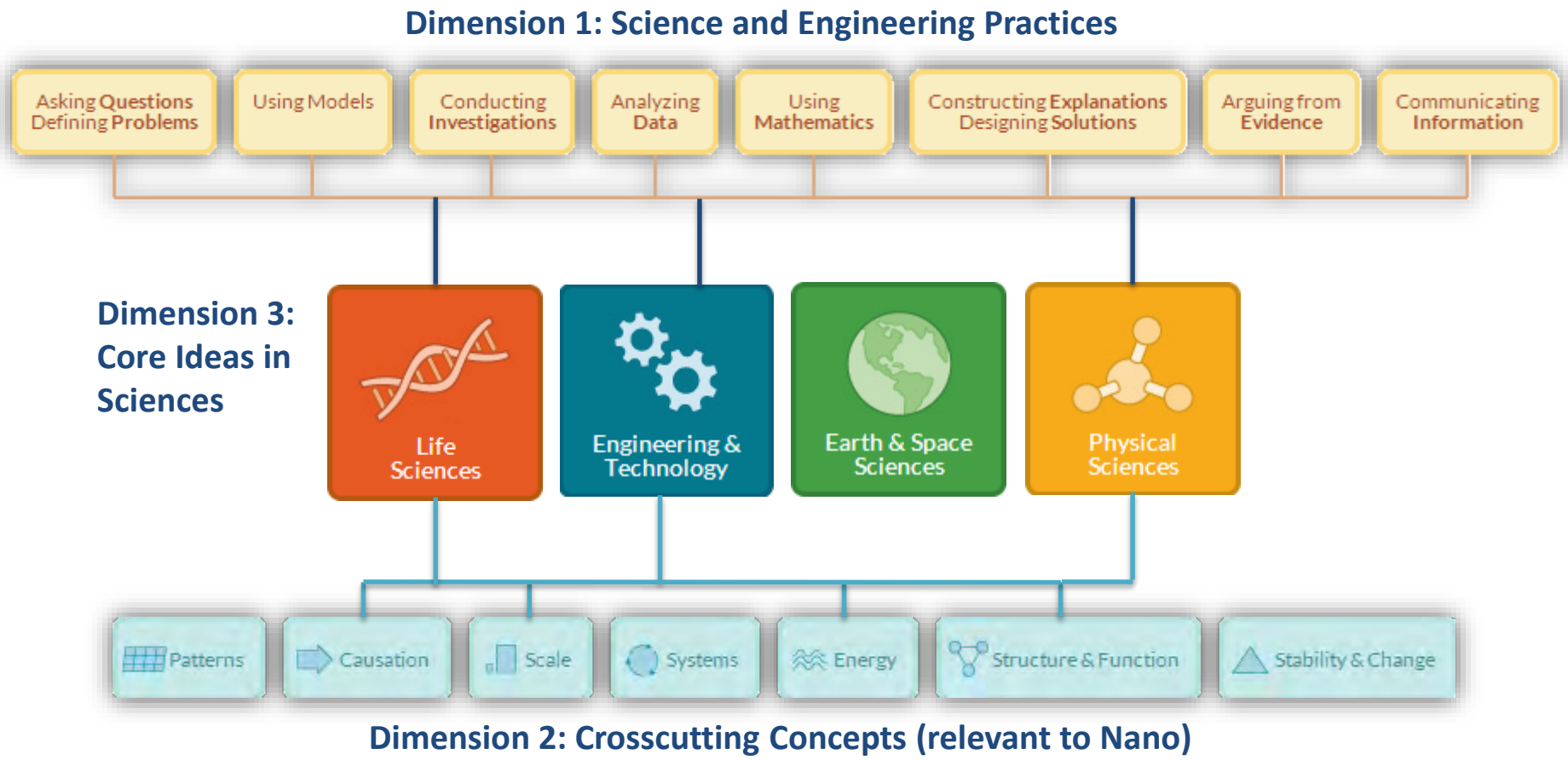
- ***Horizontal integration → Breadth of knowledge***
  - Materials science integrates physics, chemistry, biology, mathematics, and engineering
  - Broad, flexible understanding of STEM
  - The **future**: Materials-based technologies like nano and biotech will drive a large portion of the global economy



MWM integrates STEM learning



Example: Use MWM's Nano Crosscutting Concepts to Meet U.S. NGSS Engineering Standards



Adapted from Concord Consortium NGSS Pathfinder: http://concord.org/ngss/

Elements of MWM's Approach

- ***Vertical integration → Depth of knowledge***
  - Mastering fundamental concepts early on prepares students for college and career
- ***Community participation***
  - MWM brings students, teachers, parents, industrial partners, and government sponsors together
  - Leads to maximum economic and social impact within a given regional community

Teachers exploring MWM

Elements of MWM's Approach

- ***Student-led discovery and innovation***
  - Students ask questions, perform experiments, analyze data, and use findings to create new products
  - Teachers are facilitators of independent learning

Students using MWM at their schools!

Hands-on Engineering Practice

- Real-world contexts engage students of ***many ability levels***, not just those already inclined toward STEM

- Multiple solutions require ***creative thinking, alternative choices,*** and ***cooperative problem solving***

Real-world problems often require thinking outside the box, and design develops this ability

Engaging Students in Real-World Design

Design of a sun alert patch

Water level sensor

Designing an insulating package

Design of a traffic switch system

Smart cane for the blind

Design of concrete receptacle for local parks

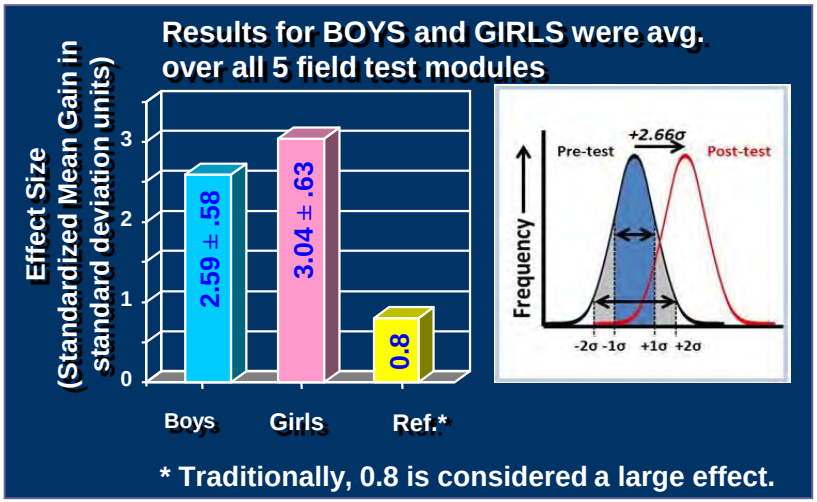
MWM's Proven Success

- A national field study of the pre/post-test gain of more than 3,000 students using our modules showed that the class mean typically improved 2-3 standard deviations, compared to 0.8 standard deviation for a traditional class.

Distribution of Science Courses

NORTH-WEST	NORTH-CENTRAL	NORTH-EAST
Physics	Chemistry	Chemistry
Physical Science (3)	Chemistry Honors (2)	Chemistry II (2)
Earth Science	Physics	Chemistry Honors
Chemistry in the Community	Conceptual Physics	Pre AP Chemistry
	Physical Science (3)	Physics
	General Science (2)	Conceptual Physics
	Biological Applications	Earth Science
		Principles of Technology (2)
SOUTH-WEST	**SOUTH-CENTRAL**	**SOUTH-EAST**
Chemistry (3)	Chemistry (3)	Chemistry (3)
Physics	Advanced Chemistry	Analytical Chemistry
AP Environmental Science	Physics	Physics (2)
Global Life Science	Physical Science	Environmental Science
	Biology Honors	Science Technology Society

Positive Student Gains

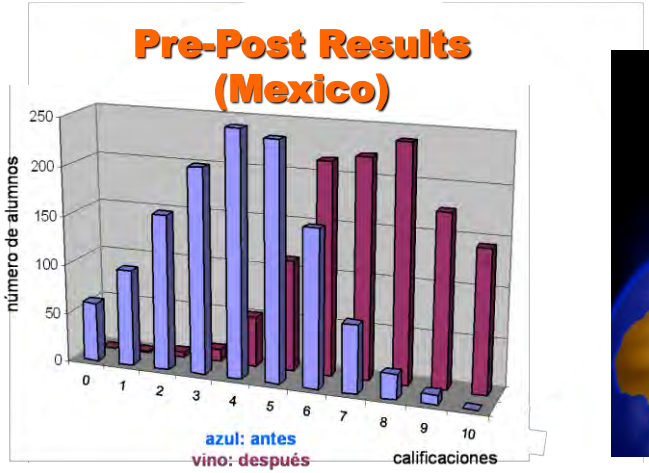


Diverse School Locales

Large metro city (>250,000)	8% of sample
Midsize city (<250,000)	12%
Suburb of a large city	20%
Suburb of a midsize city	10%
Small town (2,500-25,000)	12%
Rural within a metro area	26%
Rural outside a metro area	12%

MWM's Proven Success

- The average achievement gain of 2.5 sigma is ***regardless of student gender, background, classroom setting, or teacher experience***
- MWM has been used by 150,000 students across the U.S., Mexico, China, Qatar, and Singapore, making it a global effort
  - Similar gains obtained in Mexico, China and Middle East (Qatar).



Strengths: Futuristic Relevance

- We have learned that we can introduce nanoscience to children as young as 5th grade
- Our approach is not based on current needs but the needs of industry and society ***7-10 years from now***.
- Nanotechnology is the driver of all future technologies and industries!

Strengths: Partners and Community

- Community models
  - ***Mexico***: CIMAV, state departments of education, Chihuahua cement company, schools in region

  - ***Qatar***: Petrochemical industry, University of Qatar, local schools and government

Classroom Enhancement with i-MWM

Good education technology supports students' active learning and transforms teacher' classrooms!

Passive

replacement

enhancement

transformation

Active

Adaptive, student-centered classrooms!

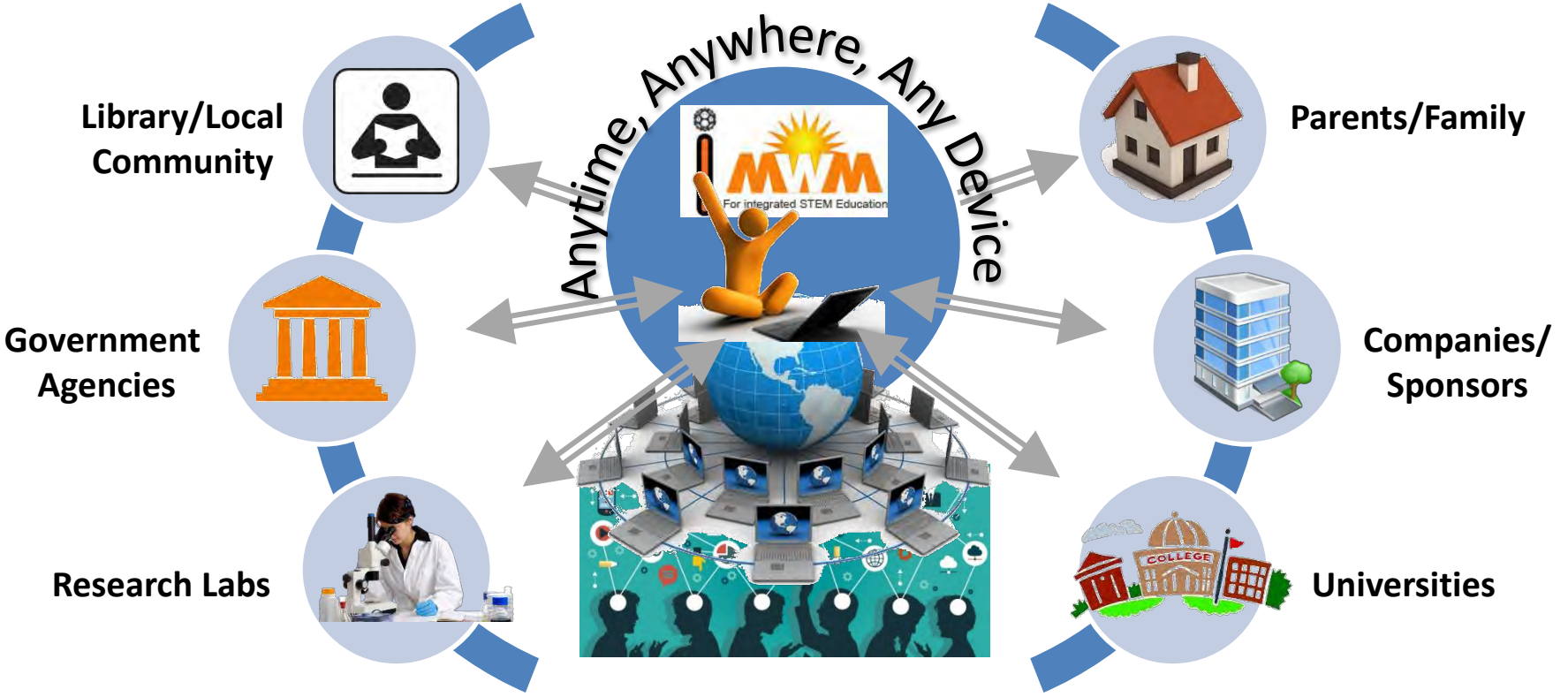
Interactive i-MWM!

Advantages of Mobile Platform

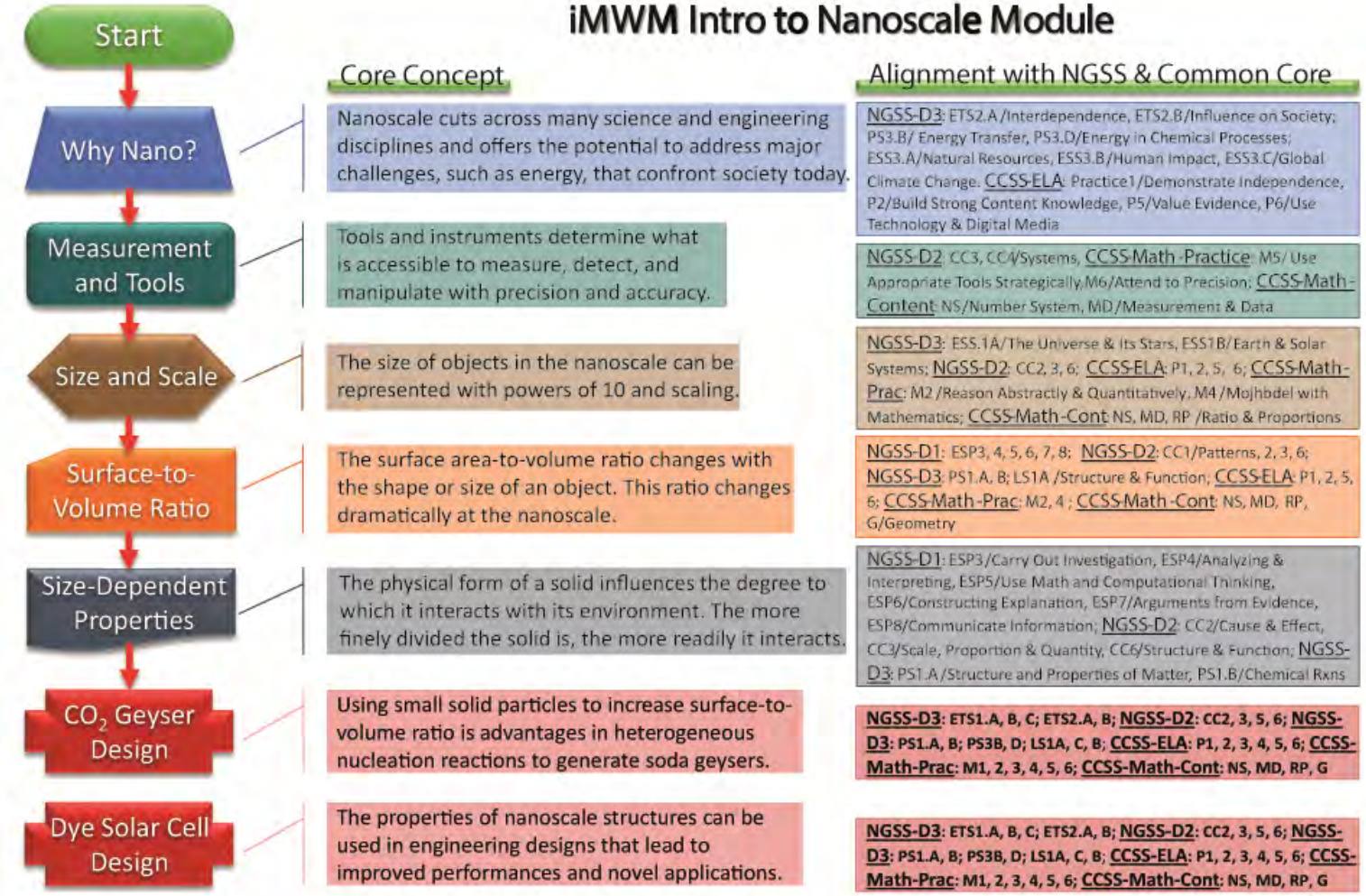
- Decreasing cost
- Broader access
- Rapid assessment feedback for teachers
- Increasing effectiveness, flexibility, and ease of implementation

- i-MWM consists of interactive, rich immersive multimedia STEM curricula for use on mobile devices that enable anytime, anyplace learning
- Mobile devices enhance learning ***across subjects***
- Students take more responsibility for their own learning and are more ***interested, motivated, and engaged*** in learning activities

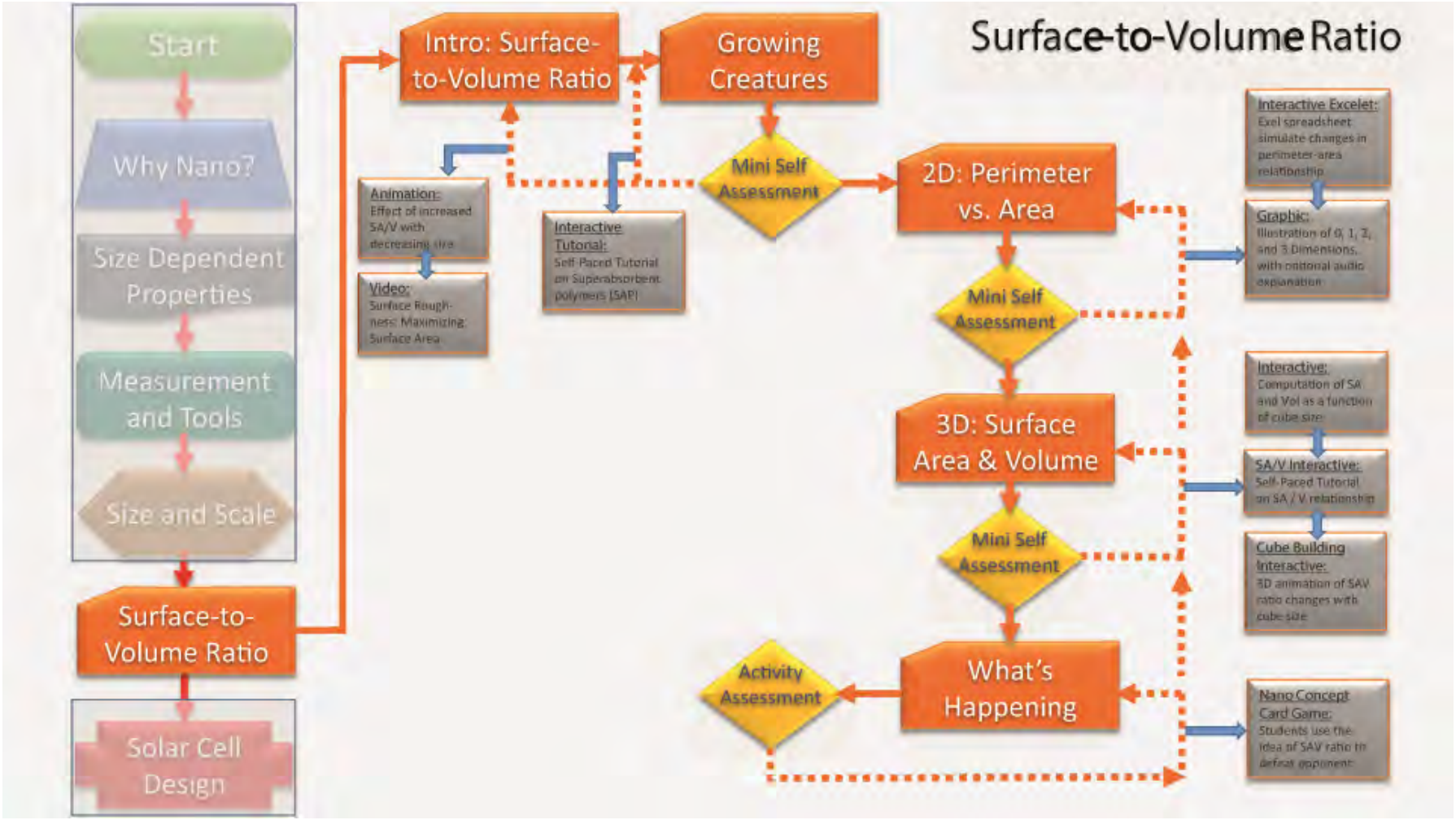
Interactive i-MWM!



“Intro to Nano” Curriculum Design

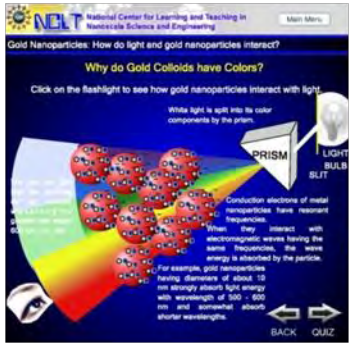


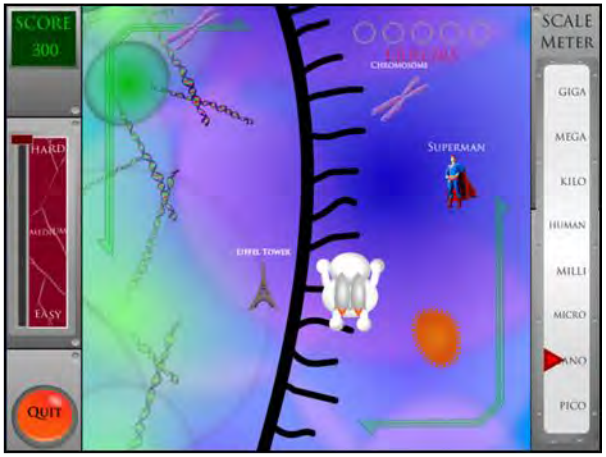
“Surface-to-Volume” Activity Design



Engaging Simulations & Games

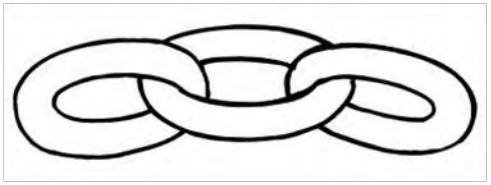
- Users of ***interactive simulations*** and ***games*** significantly outperform their peers who use traditional classroom methods
- Games are highly motivating
- Students remember almost ***90% of information if they complete a task, even if it is a simulation***





i-MWM Serves as a…

- ***Classroom portal***
  - Seamless integration with classroom activities → record data, observations, and predictions for design projects
  - Link out of class assignments to in-class discussion → upload photos or observations pertinent to class



LINKING

i-MWM Serves as a…

- ***Cyber platform for community-based activities***
  - Student innovation gallery
  - STEM undergraduate talks (student chapters of professional societies)
  - STEM career talks
  - Concept-to-application talks
  - Teacher resources
  - Professional researchers as mentors

Community collaboration is fundamental for success

Thank You!

I look forward to partnering with you in order to improve STEM education in America together!

Sampling MWM Activities

- Overview of i-MWM's Intro to the Nanoscale Module

[i-MWM Sample Activity]

- Video introduction of students engaging in MWM activities and design projects

[Key Features]

[Design Process]

[Student Responses]

Contact Info

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