STEM Curriculum Planning Guide

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

STEM Unit Title	**Using Nanoparticles to Deliver Targeted Chemotherapy Drugs**
Economic Cluster	Human Performance & Medicine, Advanced Manufacturing & Materials, Sensors
Targeted Grades	9 - 12
STEM Disciplines	Science, Technology, Engineering and Math
Non-STEM Disciplines	English Language Arts, Medicine and Art

Section I: STEM Unit Overview

Unit Overview

Cancer is a part of our daily lives. The treatment for most cancer patients is usually achieved through aggressive chemotherapy. Unfortunately this treatment has major side effects as it destroys not only the cancer cells but also the non-cancerous cells around it. Is there a method of treating cancer using nanotechnology to help target just the cancer cells? In this STEM unit, students gain an understanding of the relative size of nanoparticles and how nanoparticles can be used to deliver medicine. The students will research how normal cells are different from cancer cells and research current innovative cancer treatments besides surgery and traditional chemotherapy. In the engineering design challenge, students will be working as researchers in a race for a Nobel Prize in Medicine. They are to design and build a large-scale conceptual model of a targeted drug delivery system using nanoparticles that only kill cancer cells. Their final presentation will be to the Nobel Prize committee explaining how this conceptual model should move into prototyping phase.

Essential Question

How can nanotechnology impact the medical treatment of diseases such as cancer? From an economical and scientific perspective, why does size matter in medicine?

Enduring Understanding

1. Nanoparticles are important to industrial and medical applications because of their small size and high aspect ratio in comparison to other commonly used manufacturing or biological materials.
2. Nanoparticles can be designed to specifically target cancer cells because of surface markers followed by activation with an energy source such as light.

Engineering Design Challenge

You are a team of oncologists addressing the issue of deleterious side effects of traditional chemotherapy medicines. Your goal is to develop a nanodrug delivery system that will only target cancer cells which will minimize whole-body side effects. You must address three engineering constraints: 1) the delivery of the Nano-Drug Delivery Mechanism (NDDM); 2) selectivity of normal vs. cancer cells; 3) demonstration of successful drug delivery. You must perform this task under the constraints given. Your team will present the results of your research to the Nobel Prize Award Committee.

Time and Activity Overview

Day	Time Allotment	Actvities
1	50 minutes	Pre Test What are the advantages and disadvantages of being small?
2	50 minutes	Nano-scale Introduction
3	50 minutes	Guided Nanotechnology Research
4	50 minutes	Cancer Research
5	50 minutes	Engineering Design Challenge
6	50 minutes	Engineering Design Challenge Continued
7	50 minutes	Engineering Design Challenge Continued
8	50 minutes	Engineering Design Challenge Continued
9	50 minutes	Presentations of NDDM

10	50 minutes	Post Test

Pre-requisite Knowledge & Skill

Internet as a Research Tool
Computation using a Calculator
Metric Unit Conversions

Academic Content Standards

Add Standard	Mathematics	
Grade/Conceptual Category	High School: Geometry	
Domain	Modeling with Geometry	
Cluster	Apply geometric concepts in modeling situations	
Standards	CCSS.Math.Content.HSG-MG.A.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).	

Add Standard	Mathematics	
Grade/Conceptual Category	High School: Number and Quantitiy	
Domain	Quantities	
Cluster	Reason quantitatively and use units to solve problems.	
Standards	CCSS.Math.Content.HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. CCSS.Math.Content.HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.	

Add Standard	English Language Arts
Grade	11-12
Strand	Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–12
Topic	Text Types and Purposes
Standard	CCSS.ELA-Literacy.WHST.11-12.1 1. Write arguments focused on discipline-specific content. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented. CCCSS.ELA-Literacy.WHST.11-12.2 2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Add Standard	English Language Arts	Ohio
Grade	11-12	
Strand	Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–12	
Topic	Research to Build and Present Knowledge	
Standard	CCSS.ELA-Literacy.WHST.11-12.7 7. Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. CCSS.ELA-Literacy.WHST.11-12.8 8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.	

Add Standard	English Language Arts	Ohio
Grade	11-12	
Strand	Speaking and Listening Standards 6–12	
Topic	Presentation of Knowledge and Ideas	
Standard	CCSS.ELA-Literacy.SL.11-12.4 Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.	

Add Standard	Social Studies	Ohio
Grade		
Theme		
Strand (pk-8 only)		
Topic		
Content Standard		

Add Standard	Science	Ohio
Grade		
Theme		
Topic		
Content Standard		

Add Standard	Science	Ohio
Strand	Biology	
Course Content	Heredity	
Content Elaboration	The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different genes are active in different types of cells, influenced by the cell's environment and past history.	

Add Standard	Science	Ohio
Strand	Biology	
Course Content	Diversity & Interdependence of Life	
Content Elaboration	The effects of physical/chemical constraints on all biological relationships and systems are investigated.	

Add Standard	Science	Ohio
Strand	Biology	
Course Content	Cells	
Content Elaboration	Every cell is covered by a membrane that controls what can enter and leave the cell. A living cell is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Most cells function within a narrow range of temperature and pH. Even small changes in pH can alter how molecules interact.	

Add Standard	Fine Arts
Grade	9-12
Subject	Visual Arts Standards
Standard	Producing/Performing (PR)
Benchmark	HS Intermediate
Indicator	1PR Demonstrate proficient technical skills and craftsmanship with various art media when creating images from observation, memory, or imagination. 2PR Make informed choices in the selection of materials and techniques as they relate to solving a visual problem.

Add Standard	Fine Arts
Grade	9-12
Subject	Visual Arts Standards
Standard	Producing/Performing (PR)
Benchmark	HS Accelerated
Indicator	3PR Solve visual art problems that demonstrate skill, imagination and observation.

Add Standard	Technology
Grade	9-12
Standard	Standard 1: Nature of Technology
Benchmark	Benchmark A: Synthesize information, evaluate and make decisions about technologies.
Indicator	10.1. Describe how the rate of technological development and diffusion is increasing rapidly (e.g., a computer system chip has been adapted for use in toys and greeting cards).

Add Standard	Technology
Grade	9-12
Standard	Standard 1: Nature of Technology
Benchmark	Benchmark B: Apply technological knowledge in decision-making.
Indicator	12.1.Design/construct a model to demonstrate how all components contribute to the stability of a technological system

Add Standard	Technology
Grade	9-12
Standard	Standard 1: Nature of Technology
Benchmark	Benchmark C: Examine the synergy between and among technologies and other fields of study when solving technological problems.
Indicator	9.2. Describe how technologies are, or can be, combined (e.g., a computer-controlled surgical laser scalpel represents the combination of physical, information and bio-related technology).

Add Standard	Technology
Grade	9-12
Standard	Standard 2: Technology and Society Interaction
Benchmark	Benchmark A: Interpret and practice responsible citizenship relative to technology.
Indicator	9.2. Understand that ethical considerations are important in the development, selection and use of technologies.

Add Standard	Technology
Grade	9-12
Standard	Standard 3: Technology for Productivity Applications
Benchmark	Benchmark A: Integrate conceptual knowledge of technology systems in determining practical applications for learning and technical problem-solving.
Indicator	12.1. Research and create technology systems, resources and services to solve technical problems.

Add Standard	Technology
Grade	9-12
Standard	Standard 4: Technology and Communication Applications
Benchmark	Benchmark A: Apply appropriate communication design principles in published and presented projects.
Indicator	9.1. Format text, select color, insert graphics and include multimedia components in student-created media/ communication products.

Add Standard	Technology
Grade	9-12
Standard	Standard 5: Technology and Information Literacy
Benchmark	Benchmark A: Determine and apply an evaluative process to all information sources chosen for a project.
Indicator	10.1. Examine information for its accuracy and relevance to an information need (e.g., for a report on pollution, find information from sources that have correct and current information related to the topic).

Add Standard	Technology
Grade	9-12
Standard	Standard 5: Technology and Information Literacy
Benchmark	Benchmark C: Formulate advanced search strategies, demonstrating an understanding of the strengths and limitations of the Internet, and evaluate the quality and appropriate use of Internet resources.
Indicator	11.3. Develop a systematic approach to judge the value of the retrieved Web information. 12.3. Develop a systematic approach to judge the value of the retrieved Web information.

Add Standard	Technology
Grade	9-12
Standard	Standard 6: Design
Benchmark	Benchmark A: Identify and produce a product or system using a design process, evaluate the final solution and communicate the findings.
Indicator	10.5. Explain that design problems are seldom presented in a clearly defined form (e.g., problems often involve competing constituencies, undiscovered constraints and unidentified regulations). 11.1. Explain how a design needs to be continually checked and critiqued, and must be redefined and improved (e.g., the heating system design for one home may not be the best for another, given a different location, shape or size). 11.2. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product (e.g., proposed or existing designs in the real world). 12.1. Implement the design process: defining a problem; brainstorming, researching and generating ideas; identifying criteria and specifying constraints; exploring possibilities; selecting an approach, developing a design proposal; making a model or prototype; testing and evaluating the design using specifications; refining the design; creating or making it; communicating processes and results; and implement and electronically document the design process.

Add Standard	Technology
Grade	9-12
Standard	Standard 6: Design
Benchmark	Benchmark B: Recognize the role of teamwork in engineering design and of prototyping in the design process.
Indicator	9.2. Explain how a prototype is a working model used to test a design concept by making actual observations and necessary adjustments. 9.6. Describe the importance of teamwork, leadership, integrity, honesty, work habits and organizational skills of members during the design process. 10.1. Build a prototype to test a design concept and make actual observations and necessary design adjustments. 10.2. Design a prototype using quality control measures (e.g., measuring, checking, testing, feedback). 11.4. Understand that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments. 11.6. Demonstrate the importance of teamwork, leadership, integrity, honesty, work habits and organizational skills in the design process.

Add Standard	Technology
Grade	9-12
Standard	Standard 7: Designed World
Benchmark	Benchmark F: Classify, demonstrate, examine and appraise medical technologies.
Indicator	9.5. Investigate emerging (state-of-the-art) and innovative applications of medical technologies. 11.2. Describe how medicines and treatments may have both expected and unexpected results.

Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

Performance Task, Projects	NDDM Prototype Student Presentations Nano-Scale Worksheet Nanotechnology Webquest Cancer Webquest
Quizzes, Tests, Academic Prompts	Pre-Test Post-Test Exit Slip
Other Evidence (e.g. observations, work samples, student artifacts, etc.)	Peer Review Daily Activity Rubric
Student Self- Assessment	Self Assessment (Daily Activity Rubric)

Technology Integration

ADISC Technology Integration Model*

	Type of Integration	Application(s) in this STEM Unit
A	Technology tools and resources that support students and teachers in ***adjusting, adapting, or augmenting*** teaching and learning to meet the needs of individual learners or groups of learners.	Interactive Whiteboard Video Interactive Animations Computers
D	Technology tools and resources that support students and teachers in ***dealing effectively with data***, including data management, manipulation, and display.	Video Editing Software Computers
I	Technology tools and resources that support students and teachers in conducting ***inquiry***, including the effective use of Internet research methods.	Internet Research Computers
S	Technology tools and resources that support students and teachers in ***simulating*** real world phenomena including the modeling of physical, social, economic, and mathematical relationships.	Nano Drug Delivery Mechanism Model Calculator Video Editing Software Computers
C	Technology tools and resources that support students and teachers in ***communicating and collaborating*** including the effective use of multimedia tools and online collaboration.	Camera Video Camera Smartphone Cell Phone Presentation Software Video Editing Software Computers
	**The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton*	

Career Connections

Career Description

Biochemist - Studies the chemical and physical processes of cells and organisms. For example, how humans or other species reacts to specific medicines or chemicals, how algae can be used to produce biodiesel, the role of genetics in diseases, and in forensic science.

Biologist - Studies living things and their relationship to the environment. For example, marine and other aquatic species, plants and agriculture, a virus or bacteria, and wildlife.

Biomedical Engineer - Develops devices and procedures that solve medical and health related problems. For example, prosthetic limbs and artificial organs, ultrasound or other medical imaging devices, genetic engineering of plants or animals, and medical devices like pacemakers.

Chemist - Studies the atomic composition and structural features of substances. For example, design and production of medicinal drugs or industrial chemicals, improving fuel cell reactions, and creating more environmentally friendly plastics.

Electrical Engineer - Develops and improves products that are powered by or produce electricity. For example, electrical power generation and transmission, computers and electronics, control systems for aircraft and spacecraft power systems, audio and video signal processing, and communication systems.

Materials Engineer - Develops and improves materials used in manufacturing and production. For example, high temperature ceramics for supersonic aircraft and spacecraft, durable glass for smartphones and other displays, composite materials for bicycles and snowboards, biodegradable polymers, and superconducting metal alloys.

Medical Technologist - Also known as a clinical laboratory scientist, conducts diagnostic laboratory tests that are important in detecting, analyzing, and treating infections and disease. For example, blood and urine analysis, skin and other organ tumor analysis, and bone marrow analysis.

Molecular Biologist - Studies the molecular aspects of genetic material. For example, the interaction of cells, enzymes, DNA, RNA, and protein synthesis.

Oncologist - A medical doctor who studies and treats cancer. For example, working in regular hospitals, cancer treatment centers, cancer research centers, pharmaceutical companies, and universities.

Pharmaceutical Researcher - Conducts research to discover or develop new kinds of medications and drugs. For example, the biochemical and physiological effects of medical drugs, drug design and synthesis of new drugs, drug formulation for delivery and stability, and the interaction of multiple drugs.

Pharmaceutical Sales - works with organizations and drug companies introducing new compounds. For example, providing product information, answering questions on product use, and delivering product samples.

Physicist - Studies the science of matter and energy and how forces interact. For example, studying the atmosphere and weather formation, space weather and its impact on Earth, the production and propagation of radiation, and developing new or improved lasers or other optical components.

Section II: STEM Lesson Plan

Title of Lesson

Day 1 - What are the advantages and disadvantages of being small?

Time Required

50 minutes

Materials

Pre-test (Appendix A) (1 per student)
Pre-test Answer Key (Appendix B) (1 per teacher)
Video Clips - Honey I Shrunk the Kids
Computer with video display capabilities (1)
Exit Slip (Appendix C) (1 per student)

Objectives

Students will be able to justify the need for small-scale technology.

Instructional Process

1. Administer Pre-Test (20 minutes)

2. Show video clip of: “Honey I Shrunk the Kids” (http://www.youtube.com/watch?v=ToGv7rF8kVk (20:00 to 25:00). Alternatively, show the movie trailer at http://www.youtube.com/watch?v=AMGZwxc9VqI) (5-8 minutes)

3. Lead a discussion on the advantages and disadvantages of being small. (20-25 minutes)
Suggested discussion questions include:

What are the advantages/ disadvantages of being small?
Are there any human qualities that could be negated by shrinking?
Are there any human qualities that could be improved by shrinking?
What technologies have shrunk throughout the past decade?
What advantages could occur from technologies?
Are there disadvantages to shrinking technologies?
Besides electronics, what other products have “shrunk”?
What science concepts have allowed for this shrinking of our everyday products?

Differentiation

The Pre-Test should be accommodated and or modified based on student needs. Discussions can be led in smaller groups if desired.

Assessments

Pretest (Appendix A)
Exit Slip (Appendix C)

Section II: STEM Lesson Plan

Title of Lesson — **Day 2 - Nano-Scale Introduction**

Time Required — 50 Minutes

Materials

Nano-Scale Calculations Worksheet (Appendix F) (1 per student)
Nano-Scale Calculations Worksheet Answer Key (Appendix G) (1 per teacher)
Pencils (1 per student)
Paper (1 per student)
Calculator (1 per student)
Meter Stick (1 per team)
Computers with Internet access (1 per team)
Computer with Projector and Internet capabilities
Scale of Universe Online Interactive (http://scaleofuniverse.com/)
Ranking of Items Activity (Appendix D) (1 per student)

Objectives

The student will be able to:

1. Perform unit conversions.
2. Demonstrate comprehension of the scale and order of magnitude of units of measurement.
3. Given units of measurement, solve a proportion.

Instructional Process

1. Allow time for the students to complete the “Ranking of Items” activity. Explain to them they are to rank the items according to size based on what they think.

2. Show the “Scale of the Universe” Online Interactive (http://scaleofuniverse.com/) and have the students self-correct their rankings.

3. Allow time for students to complete the “Nano-Scale Calculations” activity. The remainder of the worksheet should be assigned as homework.

4. Circulate amongst the students and provide scaffolding as necessary.

5. At the end of class, have the students revisit their “Ranking of Items” and reevaluate their rankings.

Differentiation

Team students with diverse backgrounds and experiences. See alternative version of unit conversion worksheet, "Nano-Scale Calculations Worksheet (Differentiated)" (Appendix H) .

Assessments

Ranking of Items (Appendix D)
Nano Scale Worksheet (Appendix F)

Section II: STEM Lesson Plan

Title of Lesson	**Day 3 - Guided Nanotechnology Research**
Time Required	50 minutes
Materials	Computers with Internet access (1 per 2 students) Nanotechnology Research Questions (Appendix J) (1 per student) Nanotechnology Research Questions Answer Key (Appendix K) (1 per teacher)
Objectives	Student will be able to: 1. Describe the field of nanotechnology 2. List three applications of nanotechnology 3. Properly select and accurately cite resources
Instructional Process	1. Discuss with students that they will be researchers investigating the different aspects and application of nanotechnology. 2. Remind students the requirements of a credible website and how to properly document sources. 3. Distribute the "Nanotechnology Research" questions for students to complete in pairs.
Differentiation	The Nanotechnology Research questions can be modified to support student needs. Additional websites can be provided, and the process can be supported by guiding questions.
Assessments	Nanotechnology Research Questions (Appendix J)

Section II: STEM Lesson Plan

Title of Lesson	**Day 4 - Cancer Research**
Time Required	50 minutes
Materials	Computers with Internet Access (1 per student) Disease of Cancer Webquest Activity (Appendix L) (1 per student) Disease of Cancer Webquest Activity Answer Key (Appendix M) (1 per teacher)

Objectives	Students will be able to: 1. List and explain the three main types of current cancer treatments. 2. Explain the functions of various nano-drug deliverers that are currently in use.
Instructional Process	1. Elicit student input regarding various applications of nanotechnology based on their research. 2. Inform them that today, they will specifically explore the medical application of nanotechnology - nano-drug delivery. 3. Hand out the “Disease of Cancer Webquest” and have the students complete it working in pairs. 4. Remind students to include references for the information obtained.
Differentiation	Consider providing a list of suggested resources and guiding questions for support during the webquest activity.
Assessments	Disease of Cancer Webquest Activity (Appendix L)

Section II: STEM Lesson Plan

Title of Lesson — **Days 5 - 8 - The Engineering Design Challenge**

Time Required — 200 minutes (4 periods)

Materials

Pre-lesson activity:
Have either of the following available:
Computer with Internet access (1 per 2 students)
Copies of the web page "Wriggling Away From Cancer" (http://www.popsci.com/node/24500)

Lesson:
1 copy per student of each of the following:
- The Engineering Design Challenge (Appendix N)
- The Engineering Design Process (Appendix O)
- The Engineering Design Challenge Rubric (Appendix P)
- The Presentation Rubric (Appendix Q)
- The Daily Performance Rubric (Appendix R)

The following materials should be on hand for the students to use to construct their model:
(NOTE: The quantity listed would be suitable for 1 class of 24 students working in teams of 4)

rubber tubing (10 m)
pipe insulation tubing (10 m)
marbles (30)
ball bearings (30)
paraffin wax (453 g)
chocolate (6 large bars)
packing peanuts (3 L)
water (no limit)
Velcro ®(1 m)
magnets (24)
instant snow (100 g)
sponges (24)
craft beads (36)
Styrofoam ® (2 m)
other craft supplies
heat lamp (6)
butane burner (6)
induction coils (6)

The following materials can be used by students to document and record their process and prototype:
Digital Camera (6)
Video camera (6)
Computer with video editing software such as Window MovieMaker or Mac iMovie (6)
Computer with Internet access to free online picture and video editing software (see printable resources) (6)

Other materials can be supplied if necessary. The amount of each material is not crucial, just make sure there is enough for the students to be creative.

Students may supply thier own materials with teacher approval.

Objectives

The student will be able to:
1. Design and construct a large scale model of a Nano-Drug Delivery Mechanism.
2. Improve their collaboration skills.

Instructional Process

NOTE: The Daily Performance rubric (Appendix R) should be used by the teacher to assess the students each day.

Day 5 -
Pre-Lesson Activity:
1. Either have the students view and read "Wriggling Away from Cancer" (http://www.popsci.com/node/117368)

2. Lead a brief discussion about the article, lead the students to the understanding that this is what their challenge will be!

Lesson:
1. Distribute the Engineering Design Challenge and lead a discussion on the challenge requirements.

3. Emphasize the 3 constraints for their prototype: 1) the delivery of the Nano-Drug Delivery Mechanism (NDDM); 2) selectivity of normal vs. cancer cells; 3) demonstration of successful drug delivery.

4. Hand out the Engineering Design Process and discuss with the students the cyclical nature of the process. Emphasize that it is NOT the scientific method. Explain how engineers use the process everyday.

5. Allow time for student-team planning and work on the design challenge.

Days 6, 7 and 8 -

1. Students should continue to work on completion of the Engineering Design Challenge.

2. On Day 7, introduce the Final Presentation Assignment and provide students with the presentation rubric and any technology resources they may need.

Differentiation

Structured brainstorming session may be utilized, and additional guidance should be provided depending on the students' comfort level with inquiry experiences.

Assessments

NDDM Prototypes
Daily Performance Rubric (Appendix R)
Engineering Design Rubric (Appendix P)

Section II: STEM Lesson Plan

Title of Lesson	**Day 9 - Presentations of NDDM and World Treatment of Cancer**
Time Required	50 minutes
Materials	Access to a laptop or desktop computer (with Microsoft PowerPoint® installed or other presentation software) connected to a projector screen may be needed. Access to an overhead projector may be needed. Access to Internet may be needed. Copies of Presentation Rubric (Appendix Q)

Objectives	The student will be able to: 1. Speak in front of an audience. 2. Demonstrate their knowledge gained about cancer and nanotechnology.
Instructional Process	1. Give students the opportunity to set up any necessary equipment needed for their presentations at the beginning of class or even earlier if possible. 2. Let each team make their presentation within a preset time limit. A time limit of six minutes or less is recommended. This could include a couple of minutes for questions and answers. 3. Student teams should know in advance if they will be presenting on this day and the order of presentations. 4. The instructor should take extra care to make sure that every team gets equal amount of time. If the instructor cannot fit all team presentations in one class meeting, then the remaining presentations should take place at the beginning of the following class (Day 10). 5. The instructor or panel of judges will use the rubric to evaluate each presentation. 6. Announce the winning team at the end of class if all presentations fit in this class meeting. Note: The role of Nobel Prize in Medicine committee may be played by the instructor or a designated guest or guests. The instructor may also invite several guests that could serve as a panel of judges representing the committee.
Differentiation	The Final Presentation assignment can be differentiated to support a number of different student interests and prior experiences. Technology such as video editing software may be considered if available.
Assessments	Presentation Rubric (Appendix Q)

Section II: STEM Lesson Plan

Title of Lesson | **Day 10 - Post Test**

Time Required: 20 minutes

Materials:
Post Test (1 per student) (Appendix A)
Post Test Answer Key (1 per teacher) (Appendix B)

Objectives: The student will demonstrate knowledge achieved by completing the Post-Test.

Instructional Process:
1. Administer the Post-Test.

Differentiation: The Post-Test should be modified and/or accommodated based on the learning needs of the students in the class.

Assessments: Post Test (Appendix A)

Section III: Unit Resources

Materials and Resource Master List

Day 1

Pretest (Appendix A) (1 per student)
Pretest Answer Key (Appendix B) (1 per teacher)
Video clips - Honey I Shrunk the Kids and AFRL
Computer with video display capabilities (1)
Exit Slip (Appendix C) (1 per student)

Day 2

Nano-Scale Calculations Worksheet (Appendix F) (1 per student)
Nano-Scale Calculations Worksheet Answer Key (Appendix G) (1 per teacher)
Pencils (1 per student)
Paper (1 per student)
Calculator (1 per student)
Meter Stick (1 per team)
Computers with Internet access (1 per team)
Computer with Projector and Internet capabilities
Scale of Universe online interactive (http://scaleofuniverse.com/)
Ranking of items handout (Appendix D) (1 per student)

Day 3

Computers with Internet access (1 per 2 students)
Nanotechnology Research questions (Appendix J) (1 per student)
Nanotechnology Research questions Answer Key (Appendix K) (1 per teacher)

Day 4

Computers with Internet Access (1 per student)
Disease of Cancer Webquest Activity (Appendix L) (1 per student)
Disease of Cancer Webquest Activity Answer Key (Appendix M) (1 per teacher)

Days 5 - 8

Pre-Lesson Activity:
Have either of the following available:
Computer with Internet access (1 per 2 students)
Copies of the web page "Wriggling Away From Cancer" (http://www.popsci.com/node/117368)

Lesson:
1 copy per student of each of the following:
- The Engineering Design Challenge (Appendix N)
- The Engineering Design Process (Appendix O)
- The Engineering Design Challenge Rubric (Appendix P)
- The Presentation Rubric (Appendix Q)
- The Daily Performance Rubric (Appendix R)

The following materials should be on hand for the students to use to construct their model:
(NOTE: The quantity listed would be suitable for 1 class of 24 students working in teams of 4)

rubber tubing (10 m)
pipe insulation tubing (10 m)
marbles (30)
ball bearings (30)
paraffin wax (453 g)
chocolate (6 large bars)
packing peanuts (3 L)

water (no limit)
Velcro ®(1 m)
magnets (24)
instant snow (100 g)
sponges (24)
craft beads (36)
Styrofoam ®(2 m)
other craft supplies
heat lamp (6)
butane burner (6)
induction coils (6)

The following materials can be used by students to document and record their process and prototype:
Digital Camera (6)
Video camera (6)
Computer with video editing software such as Window MovieMaker or Mac iMovie (6)
Computer with Internet access to free online picture and video editing software (see printable resources) (6)

Other materials can be supplied if necessary. The amount of each material is not crucial, just make sure there is enough for the students to be creative.

Students may supply their own materials with teacher approval.

Day 9

Access to a laptop or desktop computer (with Microsoft PowerPoint® installed or other presentation software) connected to a projector screen may be needed.
Access to an overhead projector may be needed.
Access to Internet may be needed.
Classroom space for students to set up a poster presentation may be needed.
Copies of Presentation Rubric

Day 10

Post Test (1 per student) (Appendix A)
Post Test Answer Key (1 per teacher) (Appendix B)

Key Vocabulary

Aerospace - the industry concerned with the design and manufacture of aircraft, rockets, missiles, spacecraft, etc., that operate in the atmosphere and the space beyond.

Aspect Ratio - The ratio of two dimensions of something as considered from a specific direction.

Benign- Not cancerous. Benign tumors may grow larger but do not spread to other parts of the body. Also called nonmalignant.

Biocompatible- The property of being biologically compatible by not producing a toxic, injurious, or immunological response in living tissue.

Cancer - a malignant and invasive growth or tumor.

Chemotherapy- the treatment of disease by means of chemicals that have a specific toxic effect upon the disease-producing microorganisms or that selectively destroy cancerous tissue.

Clinical Trial - the scientific investigation of a new treatment that has shown some benefit in animal or laboratory studies, but that has not yet been proven effective in humans.

Deleterious - Causing harm or damage.

Encapsulate - to become enclosed in or as if in a capsule.

Infrared Radiation - Invisible radiation in the part of the electromagnetic spectrum characterized by wavelengths just longer than those of ordinary visible red light and shorter than those of microwaves or radio waves.

Laser - a device that produces a nearly parallel, nearly monochromatic, and coherent beam of light by exciting atoms to a higher energy level and causing them to radiate their energy in phase.(Light Amplification by Stimulated Emission of Radiation)

Liposome - A very tiny, fat-like particle that is made in the laboratory. In medicine, liposomes containing drugs or other substances are used in the treatment of cancer and other diseases. Drugs given in liposomes may have fewer side effects and work better than the same drugs given alone.

Macro - refers to an object that is very large in scale compared to others of its kind.

Malignant - A term for diseases in which abnormal cells divide without control and can invade nearby tissues.

Metastasis - medical use for shift of disease from one part of the body to another.

Micelles - A tiny particle made of substances that are soluble in water and that come together to form a ball-like shape. These particles can carry other substances inside them. In medicine, micelles are made in the laboratory and are used to carry drugs to body tissues and cells.

Micro - refers to any object being very small compared to others of its kind or scientifically μ= one millionth or 1x10^-6.

Micron - Also called micrometer; the millionth part of a meter.

Nanometer - a unit measuring length which is equal to one billionth of a meter or 1x10^-9.

Nanoparticles - particles with one or more dimension(s) of 100nm or less with properties different (superior) than the properties of the bulk material.

Nanotechnology - the ability to engineer structures, devices and systems at the nanometer scale (atomic, molecular and macromolecular scale) that produce properties that are different (superior) from the properties of the bulk material.

Oncology - the branch of medical science dealing with tumors, including the origin, development, diagnosis, and treatment of malignant growths.

Photoelectricity - electricity induced by electromagnetic radiation, as in certain processes, as the photoelectric and photovoltaic effects, photoconductivity, and photoionization.

Physical Property - any property used to characterize matter and energy and their interactions. A physical property can be described without changing the identity of the substance.

Radio Wave - an electromagnetic wave having a wavelength between 1 millimeter and 30,000 meters, or a frequency between 10 kilohertz and 300,000 megahertz.

Super Heating - to heat to an extreme degree or to a very high temperature.

Vesicula - small sac used to encapsulate compounds in the body.

Technical Brief

Nanotechnology refers to the use of material on an atomic or molecular scale in the range of 1 to 100 nanometers (nm).[1] A nanometer is a unit of length which is one-billionth (or 1x10^-9) of a meter. To help put it in perspective, there are about a million nanometers across the top of the head of a pin or about 70,000 nm across the width of a human hair. The diameter of a DNA double helix is around 2 nm and requires a scanning electron microscope to physically see it. A nanoparticle can be any shape (i.e., balls, cylinders, tubes, wires, shells, spheres, dots, pores, etc.) that meets the definition of a nanometer. The most commonly referred to nanomaterial are carbon nanotubes. These are hollow cylinders made entirely of carbon atoms. Think of a slinky stretched out long, but on a much smaller scale.

So why is smaller better? Like most industrial applications, factors such as cost, weight, and performance play a pivotal role in determining when and where to use nanotechnology. When we talk about aerospace or aeronautical applications, all three of these factors are considered by design engineers. Both of these high tech industries want lightweight, strong and flexible materials to help reduce costs with respect to payload and fuel consumption. I liken it to pouring a concrete slab. In the past, rebar (which is long steel rods) was placed in the middle of the poured concrete to help give support and prevent cracking. New technology uses fiber glass fillers rather than rebar to help reinforce the strength of the concrete while reducing the overall weight.[2] These smaller glass fibers have more surface area contact with the concrete which helps create a better bond. Granted, we are not worried about how much a concrete slab weighs, but when you start putting those slabs on skyscrapers it does matter.

Recently new developments with nanoparticles have shown promise in the medical field. Particles on the atomic or molecular scale can be used for the treatment of certain types of cancer. Researchers have discovered that some metallic nanoparticles (e.g., gold nanoparticles) have the tendency to bind to malignant cancer cells.[3] When these gold nanoparticles are exposed to different forms of heat (i.e., radiowaves, infrared radiation, photoelectricity, lasers, etc.) they can cause the gold to superheat and destroy the cancer cells or prevent the cells from dividing further. Scientists can control the amount of heat generated by increasing the thickness of the nanomaterial. What's nice about this technique is that healthy cells are left intact.

In cancer therapy it is critical that the distribution of active anticancer agents be controlled as much as possible in order to assure their proper efficiency and safety. Biocompatible nanocomposites provide specific biochemical interactions with receptors expressed on the surface of cancer cells. In this way, an increased intracellular concentration of drugs can be achieved in cancer cells, while normal cells are being protected from the drug. Thus, nanotechnology restricts the extent of the adverse effects of the anticancer therapy. Treatment for metastatic breast cancer, sarcoma in AIDS patients, ovarian and lung cancer is already on market or under final phases of many clinical trials, showing remarkable results. As nanotechnology is perfected, side effects due to normal cell damage will decrease, leading to better results and lengthening patient's survival.[4] A selective delivery mechanism of the anticancer agents to only the cancer cells leading to their destruction is expected to be demonstrated by the students in the STEM Lesson, "Using Nanoparticles to Deliver Targeted Chemotherapy Drugs".

So why do certain materials have enhanced characteristics when the size of the system decreases? When you start to get down to the atomic or molecular scale, the electronic properties of solids are altered with great reductions in particle size. In addition, physical properties (mechanical, electrical, optical, etc.) start to change such as surface area to volume ratio.[5] As the surface area to volume ratio increases, this allows more functional groups to be attached to the nanoparticle. These functional groups are used to help the nanoparticles bind to specific cells and act as biomarkers. This new technology can help doctors locate specific cancer cells and aid in providing exceptional images of the tumor site. It is hoped that eventually, we can not only locate but also treat cancer cells with this technique. This would help reduce the harmful side effects that cancer patients currently endure when subjected to chemotherapy and radiation treatments.

References:

1. http://www.pbs.org/wgbh/nova/body/cancer-nanotech.html
2. http://www.forta-ferro.com/?_kk=glass%20fiber%20concrete&_kt=25860148-a345-421b-8176-b330ef382647
3. http://www.livestrong.com/article/136568-non-invasive-cancer-treatments/#ixzz2DcpjPdZE
4. "Nanotechnology in cancer treatment" Maria Mironidou-Tzouveleki ; Konstantinos Imprialos ; Athanasios Kintsakis Proc. SPIE 8099, Biosensing and Nanomedicine IV, 809917 (September 12, 2011); doi:10.1117/12.898643
5. http://en.wikipedia.org/wiki/Nanotechnology

Safety and Disposal

The suggested materials for this lesson do not involve any chemicals that need any special handling or disposal methods. If heat lamps and/or induction coils are used, remind students of the electrical and heat hazards associated with their use. Remind students that they are expected to follow accepted and established laboratory safety rules, guidelines and techniques (using goggles, aprons, appropriate use of lab equipment, etc.).

References

"Honey I Shrunk the Kids"
http://www.youtube.com/watch?v=ToGv7rF8kVk

Trailer for "Honey I Shrunk the Kids"
http://www.youtube.com/watch?v=AMGZwxc9VqI

“Scale of the Universe” online interactive
http://scaleofuniverse.com/

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http://www.crnano.org/crnglossary.htm#Nanometer
http://www.nano.gov/
http://www.zyvex.com/nanotech/feynman.html

Disease of Cancer Webquest Activity
- American Cancer Society: http://www.cancer.org/research/cancerfactsfigures/cancerfactsfigures/cancer-facts-figures-2012
- Nano-Sized Drug Delivery: http://www.chem.ucla.edu/dept/Faculty/maynard/Nanoslides_SINAM_public.pdf
- Cancer and the Cell Cycle Animations: http://science.education.nih.gov/supplements/nih1/cancer/activities/activity2_animations.htm
- Nanotechnology: What it Can do for Drug Delivery: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1949907/pdf/nihms26595.pdf

"Wriggling Away From Cancer"
http://www.popsci.com/node/24500

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Section IV: Appendices

Appendix A: Day 1 – Pre/Post Test
Appendix B: Day 1 – Pre/Post Test Answer Key
Appendix C: Day 1 – Exit Slip
Appendix D: Day 2 – Ranking of Items
Appendix E: Day 2 – Ranking of Items Answer Key
Appendix F: Day 2 – Nano-Scale Calculations Activity
Appendix G: Day 2 – Nano-Scale Calculations Activity Answer Key
Appendix H: Day 2 – Nano-Scale Calculations Activity (differentiated)
Appendix I: Day 2 – Nano-Scale Calculations Activity (diff) Answer Key
Appendix J: Day 3 – Guided Nanotechnology Research Questions
Appendix K: Day 3 – Guided Nanotechnology Research Questions Answer Key
Appendix L: Day 4 – Disease of Cancer Webquest Activity
Appendix M: Day 4 – Disease of Cancer Webquest Activity Answer Key
Appendix N: Day 5 – The Engineering Design Challenge
Appendix O: Day 5 – The Engineering Design Process
Appendix P: Day 5 – The Engineering Design Challenge Rubric
Appendix Q: Day 5 – The Presentation Rubric
Appendix R: Day 5 – The Daily Performance Rubric
Appendix S: Additional Teacher Resources