Teacher's Guide

Modeling Nanotechnology Project

Grade Level: High school

Subject area(s): all subjects

Time required: Developed over 1-2 months

Learning objectives: Through research and creativity understand the science & engineering of a nanotechnology based/improved product.

Summary: Students will explore products that have been developed or enhanced by incorporation of nanotechnology. They will choose a product to investigate and then determine how this nano-product works, e.g. the science and engineering of the product. Their final part of the project will be to create a three-dimensional model of the unique nano-features of the product. The model and its scientific basis will be presented to the class. Through this hands-on project, students will learn the science and engineering underlying many products and the real-world application of nanotechnology.

Lesson Background Information: Nanotechnology is the science of the very small where scientists and engineers manipulate materials at the nanoscale to create new materials and devices. The nanoscale is defined as 1 to 100nm in one direction but many products use materials of several nanometers in diameter. Scientists have discovered that materials at the nanoscale can have very different properties than the same materials at the macro scale. For example, gold at the nanoscale interacts differently with light and may appear red or violet in color. They are utilizing these unique properties to create or enhance materials. The teacher may want to become familiar with basic information about nanotechnology by accessing materials on the internet in the resource section below.

The global nanotechnology market is expected to be more than $125 billion industry by 2024[1]. The growth rate of nanotechnology products is forecast to be 17% through 2024[2]. There are numerous products made with nanotechnology that are currently available including many consumer products. The Project on Emerging Nanotechnologies' *Consumer Product Inventory* lists over 1800 products on its website – https://www.nanotechproject.tech/. The site also has important information on the environmental, health and safety issues associated with nanotechnology.

Sources:

1. https://www.prnewswire.com/news-releases/global-nanotechnology-market-2018-2024-market-is-expected-to-exceed-us-125-billion-300641054.html
2. https://www.researchandmarkets.com/reports/4991720/global-nanotechnology-market-outlook-2024

Resources:

- Nano 101 from the National Nanotechnology Initiative: https://www.nano.gov/nanotech-101
- Nanotechnology in the real world: Redeveloping the nanomaterial consumer products inventory. M. Vance et. Al accessed at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4578396/
- An Intro to Nanotechnology from Understanding Nano.com: https://www.understandingnano.com/introduction.html
- Nanotechnology Introduction from Nanotechnology Now: https://www.nanotech-now.com/introduction.htm
- Introductory Level Nanotechnology Modules from NACK Network: http://nano4me.live.subhub.com/categories/Modules_new
- What is Nanotechnology? by Andrew Maynard: https://www.youtube.com/watch?v=DAOFpgocfrg
- What Exactly is Nanotechnology?: https://www.youtube.com/watch?v=doN3eQgo1So
- National Nanotechnology Initiative's Resources for K-12 Educators: https://www.nano.gov/education-training/teacher-resources
- NBC Learn: Nanotechnology – Super Small Science: https://www.nbclearn.com/nanotechnology
- Or, do a search on nanotechnology or nanoscale science and engineering.

Materials:

- Tri-fold display boards
- Assorted materials for creating models (teacher approved)
- Access to PowerPoint (optional for classroom presentation)

Suggested Teaching Strategies:
To help students understand how small objects on the nanoscale are, the teacher may want to start this lesson with a size and scale activity. Hands-on and interactive versions are listed below.

The Nanotechnology Timeline at nano.gov (https://www.nano.gov/timeline) would be beneficial for students read before beginning the project.

The teacher should direct students to The Project on Emerging Nanotechnologies Consumer Products Inventories for choosing their nanoproduct. This site also has useful information on environmental and societal issues associated with nanotechnology.
https://www.nanotechproject.tech/

Once the students have chosen their nanoproduct, the teacher should learn about the science and engineering of each product. Understanding what is nano about the product will assist each student/group in preparation of their models and presentations.

Size and Scale:
Size Sorting Activities:

NNCI: https://www.nnci.net/node/5305
NanoSense by SRI:
http://nanosense.sri.com/activities/sizematters/sizeandscale/SM_Lesson2Teacher.pdf (answers) and http://nanosense.sri.com/activities/sizematters/sizeandscale/SM_Lesson2Student.pdf
Interactive links:
http://www2.mcrel.org/NanoLeap/multimedia/Nanosize_me.swf
http://www2.mcrel.org/NanoLeap/multimedia/
http://scaleofuniverse.com/
http://www.eamesoffice.com/the-work/powers-of-ten/
http://www.cellsalive.com/howbig.htm
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/
Game:
http://www.nisenet.org/catalog/programs/exploring_size_-_powers_ten_game_nanodays_2011
Other:
Scale Ladder: http://www.nisenet.org/catalog/media/scale-ladder
Nanotechnology Poster with size and scale: https://www.nnci.net/node/5288

Pre-requisite Knowledge: Students should know how to perform a search on a specific topic either on the Internet or at the school's media center. They should have a basic understanding of science principles associated with their chosen product.

Safety Information: Student must have their project plans approved by the teacher before beginning. All materials that will be used must be approved as well.

Procedure for the Activity: Students may work individually or in groups or 2-4. Students are to research and create a 3-dimensional model of the unique nano feature of a particular nano product. This feature should clearly demonstrate how nanotechnology has improved that product or industry. Their project must also include a designed experiment that employs all steps of the scientific method they believe may have been necessary to create the product. Students will include a compare and contrast for their products and a cost analysis. All information will be displayed on a tri-fold project board and/or by a PowerPoint presentation. Students will present their products in a culminating activity "Nanotech Day" to prospective "consumers" (classmates, teachers, administrators, parents, etc). The *Student Guide* provides a list of requirements.

Assessment: See rubric below

Next Generation Science Standards:
HS-PS2-6: Communicate scientific and technical information about why the molecular level structure is important in the functioning of designed materials
Crosscutting: Structure and function
HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints including cost, safety, reliability and aesthetics, as well as possible social, cultural and environmental impact.

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Rubric for Assessment of Modeling Nanotechnology Project

	Exceptional 4	Satisfactory 3	Developing 2	Unsatisfactory 1	Total
Understands the nanoscience of the product	Can clearly explain nanoscience used in the product. What is unique about the product.	Provides an explanation of the nanoscience but not what is unique.	Provides some explanation but with details missing.	Does not explain the nanoscience or uniqueness of the product.	
Understands how nanoscience improves the product	Can clearly explain how nanoscience improved the product.	Provides some explanation of how product improved.	Provides less of an explanation but with details missing.	Does not explain how the nanoscience improves the product.	
Created a model of the unique nano feature of the product	Model clearly shows how nano has improved the product.	Model shows some of the nano features.	Model shows less of the nano features.	Model is poorly developed and does not show unique feature.	
Designed an experiment using the steps of the scientific method	Uses all steps of the method with well written test.	Uses most of the steps of the method with mostly clear test.	Uses some of the steps of the method but with little text.	Uses few pf the steps of the method and minimal text.	
Compared and contrasted nanoproduct and non nano version	Provided a clearly and detailed written comparison. Includes environmental and societal issues.	Provided a written comparison with missing information. Includes some environmental and societal issues.	Provided a written comparison with little text. Includes a few environmental and societal issues.	Provided very little comparison. Does not include	
Cost analysis of nano and non nano version	Provided a detailed cost analysis.	Provided a cost analysis with some detail.	Provided a cost analysis with minimal detail.	Cost analysis lacked any detail.	
Classroom presentation of project	Excellent presentation that clearly presented model and background info	Satisfactory presentation that included most of the points of the model and background information	Presentation was weak on presenting the model and background information	Presentation did not refer to the model or provide sufficient background information	