Education and Outreach: Nanotechnology Activity Guides

Rocks and Nanobots: A Societal Interaction Impact Lab

Audience: Middle school class to graduate student class
Time Needed:
Activity 1 – 10-15 minutes
Activity 2 – 10-15 minutes
Activity 3 – 30-40 minutes

Objectives:

- Identify ways in which technology has changed in the past and ways in which it might alter people's lives in the future (Activities 1 and 2)
- Describe the nature of nanotechnology and some of its present and potential future applications (Activity 2)
- Explain why different social groups might want to use the same innovation in nanotechnology or some other field in different ways (Activity 3)

Related Wisconsin Model Academic Science Standards:

- *G.8.3* Illustrate the impact that science and technology have had, both good and bad, on careers, systems, society, environment, and quality of life
- *G.8.4* Propose a design (or re-design) of an applied science model or a machine that will have an impact in the community or elsewhere in the world and show how the design (or re-design) might work, including potential side-effects
- *G.8.5* Investigate a specific local problem to which there has been a scientific or technological solution, including proposals for alternative courses of action, the choices that were made, reasons for the choices, any new problems created, and subsequent community satisfaction
- *H.8.2* Present a scientific solution to a problem involving the earth and space, life and environmental, or physical sciences and participate in a consensus-building discussion to arrive at a group decision
- *H.8.3* Understand the consequences of decisions affecting personal health and safety

Technology Education Standards:

- *A.8.2* Explain the need for and application of knowledge and skills from other disciplines when engaging in technological activities
- *A.8.3* Identify and contrast the connections and differences between technology and other disciplines
- *A.8.4* Determine that technological knowledge is valuable but not always available to everyone on an equal basis
- *A.8.6* Analyze the distribution and access of various technologies and explain how inequities occur because

of social and political systems

- *A.8.7* Discover that human will or desire can lead to the design of new technology in order to seize an opportunity or solve a problem
- *B.8.6* Identify all the resources necessary for a given system; analyze how the use of the resources will be affected by consideration for cost, availability, appropriate application, and regard for the environment
- *C.8.4* Predict possible outcomes of a newly designed technological system
- *D.8.1* Explain the difficulty in predicting the effects a new technology will have on society and the environment due to a lack of experience with the technology
- *D.8.2* Explain the importance of making projections, studying scenarios, and making thoughtful decisions because of the direct and indirect effects technology will have on the future
- *D.8.3* Contrast the advantages and disadvantages of given technology and make adjustments or develop new technologies if disadvantages outweigh the advantages
- *D.8.4* Explain why people must think about how a new technology might affect other people, societies, and the ecosystem in which we live
- *D.8.5* Explain that people can control the technologies they develop and use and that people are responsible for the effects their technology has on society and the environment

Social Studies Standards:

- *B.8.8* Identify major scientific discoveries and technological innovations and describe their social and economic effects on society
- *B.8.9* Explain the need for laws and policies to regulate science and technology
- *B.8.10* Analyze examples of conflict, cooperation, and interdependence among groups, societies, or nations
- *C.8.7* Locate, organize, and use relevant information to understand an issue of public concern, take a position, and advocate the position in a debate
- *C.8.8* Identify ways in which advocates participate in public policy debates
- *D.8.4* Describe how investments in human and physical capital, including new technology, affect standard of living and quality of life
- *D.8.11* Describe how personal decisions can have a global impact on issues such as trade agreements, recycling, and conserving the environment
- *E.8.4* Describe and explain the means by which individuals, groups, and institutions may contribute to social continuity and change within a community
- *E.8.5* Describe and explain the means by which groups and institutions meet the needs of individuals and societies

Activity Materials:

- Scissors
- A strip of paper (dimensions 216mm x 5mm)
- Pen or pencil
- Ruler
- Calculator

Activity Instructions:

This lab can be run as a unit or broken into several segments. Here are suggestions for a multi-day activity:

1. On the first day, break students into groups, describe the activity, have an initial discussion of nanotechnology, and allows the small groups to meet and discuss briefly.

2. Allow the students to spend a few days on their own researching nanotechnology and their respective identities. Possible resources include the Internet, parents, other acquaintances, newspapers (i.e., The New York Times), and popular science magazines (i.e., Scientific American).

3. Following the research period, use a class day to have the groups present their decisions and ideas and to respond to one another.

Activity 1 - What is technology and how does it impact society? (10-15 min):

1. Begin the lab by discussing technology. The purpose of this exercise is to introduce the notion that technology involves more than machines ◆ it also involves human effort and purpose. In that sense, technology is social.

    - Split the students into 5 groups and give each group a rock.
    - Ask the students what they can do with the rock.
    - Ask the students if they think the rock technology; why or why not?
    - In the discussion of (rock) technology, attempt to emphasize that the rock is technology if it serves a purpose.

2. The next section of the lab is intended to help students begin to explore the human and social aspects of familiar technologies.

    - Ask the students if they can think of a technology that has affected their lives.
    - Either choose a technology named by the students or one of your own (for instance, computers, cell phones, antibiotics, television, etc. - see Suggested Effects of Familiar Technologies sheet). List some benefits of this technology. [For a one-day lab, choose one technology to discuss. The antibiotics example works well because it relates to Activity 3. For a multiple day lab, discuss a greater number of technologies and their impacts.]
    - Now list some negative effects of the chosen technology(ies).

NOTE Before ending this portion of the lab, make sure the students understand that technology has purpose and both positive and negative effects.

Activity 2 - Nanotechnology (10-15 min.):

1. Ask students if they have ever heard of nanotechnology. (Spiderman and Minority Report both mention nanotechnology.) Have they ever heard of "nano"?

2. Introduce nanotechnology: a new technology that works on a very small scale - the scale of the atom or the molecule.

    - This scale is called the nanoscale. "Nano" means one billionth of something.
    - There are 1 billion nanometers in one meter.
    - Ask about metric/English system. 25 million nanometers in one inch. 10 hydrogen atoms next to each

other make up one nanometer.

3. *"What is nano?" Activity* - Nanotechnology works at the nanoscale. In order to understand how small a nanometer is, we can use an analogy:
    - Have students create a circle approximately 4 meters in diameter.
    - Place the four objects in the middle of the human circle and explain that they must now think of themselves as very, very small. They are standing around the circumference of a single human hair!
    - If their circle is the size of the circumference of a single human hair (which is ~50 micrometers in diameter), then which object represents the relative size of an atom?
    - The grain of sand or salt is the size of a nanometer if the circle of people is the circumference of a human hair. The grain of sand or salt and the circle of people differ in size by a factor of 10,000. Likewise, a nanometer and the diameter of a human hair differ by a factor of 10,000.

    NOTE You could include a discussion of the materials and applications of nanotechnology here. See the IPSE website http://mrsec.wisc.edu/edetc/ to learn more about nanoscale materials such as ferrofluids and carbon nanotubes.

4. One of the goals of nanotechnology is to manipulate atoms to create new materials. You can think of atoms as building blocks, like Legos. In nanotechnology, scientists use atoms to build structures, just like we use Legos.
    - Show overhead of fine-motion controller. In this picture, you can see how the different atoms (represented by different colors) are put together to create this nanoscale machine.

Activity 3 -Nanotechnology and Social Interaction: The Medical Nanobots (3-40 min.):

1. Using nanotechnology and the manipulation of atoms, scientists also hope to create nanobots nanoscale robots.
    - Show overheads of nanobots. These pictures are different people's interpretations of what nanobots might look like.
    - Nanobots might do a variety of things, from cleaning your room to making new things, but we're going to talk about medical nanobots today.

2. Our medical nanobots will have the capability to do the following:
    - Fight disease
    - Repair organs
    - Collect data, i.e. white and/or red blood cell count, blood sugar levels.

3. Offer the following scenario a new company has recently developed several types of medical nanobots.

Within the next few years, a local hospital plans to begin using these nanobots in medical treatment. Before they do, the hospital administration has gathered together representatives from a number of different areas to help answer some important questions:

- Should the medical nanobots be used at all?
- Who will pay for the nanobots (e.g., insurance companies, government, private corporations, individuals, or other)?
- Should their use be limited (e.g., otherwise terminal patients, and injuries/diseases vs. congenital problems vs. old age)?
- Who gets to control the information that nanobots can gather?

NOTE Here are some other possible questions:

- Should they be available everywhere or only in certain controlled areas? Who will pay for the controlled areas?
- Who will pay for the special safeguards that nanobots may require? Who is responsible if such safeguards should fail?
- Who is responsible for harm resulting from nanobots?
- Should use be mandated in certain cases (contagious diseases, for instance)?
- Do health care workers need permission from patients before nanobots can be used?
- Should nanobots be allowed to modify genetic patterns?

4. Now assign each group of students its identity. Each group will represent one of the following:

   - Government (including lawmakers and regulators)
   - Insurance Industry (including HMOs)
   - Health Care Workers (including doctors and nurses)
   - Patients (which should include people of varying ages and social classes)
   - Nanobot Manufacturers

5. After the educator finishes speaking, give each group an Identity Sheet. During the small group discussion, the group answer the four questions listed under (3) above (or whichever questions the educator chooses). It is important for the groups to justify their responses. They should write their answers on a large sheet of paper.

   NOTE People within groups might have different takes on questions - for instance, patients of different classes or ages, larger or smaller insurance companies, different kinds of doctors, etc. This should be encouraged to show students that no group is monolithic.

6. Once they have had a chance to talk among themselves, the students should reassemble and each group should present and justify their ideas. The goal here is to get students to teach each other about the social interests of different groups and how those interests might shape the way the nanobots might be used, if at all.

7. Ask students what they learned from the activity. Then have them come out of their identities and have the

whole class vote on whether nanobots should be used. Depending on time and the verdict of the first vote, discuss some of the other questions mentioned above or open the floor for discussion.

Concluding NOTE We hope that students will see more clearly that new technologies do not simply spontaneously come into existence, but are the result of social forces as much as physical ones. The choices that people make are important - including the choices that the students make. Remind them that new technologies usually have both positive and negative aspects and individually we should all evaluate the technology. If students would like to research nanotechnology further, please direct them to the University of Wisconsin-Madison Materials Research Science and Engineering Center education website at http://mrsec.wisc.edu/nano and encourage them to explore.

Required Background Information:

The Nanotechnology Social Interaction Lab is intended to be as self-contained as possible and to require little or no prerequisite knowledge. Nevertheless, you may wish to introduce or reinforce the following concepts prior to conducting the activities included in the lab.

Activity 1
[None]

Activity 2

- All objects are made of invisible parts called atoms.
- Atoms are very small, much too small to see or manipulate directly.
- Atoms can be held together or repelled by forces between them.

Activity 3
The concepts required for Activity 3 depend on the role-play identities chosen and the particular scenario used. You may use the five identities provided at the end of this packet or choose social interest groups that have relevance to your curriculum. If you use the identities provided, you can describe the various social groups you intend to assign to students before running the activity. Or, you might allow students some time to research and discuss the function and interests of their role-playing identity. Such preparation will be particularly important if you intend on using the lab as a means for teaching students about the perspectives of government agencies, insurance companies, manufacturers or the like. However, the lab need not be used for this purpose, and the *Identity Sheets* should contain all the information students require to take a plausible position on the scenario you choose.

Different scenarios may also require different sorts of background knowledge, though again Activity 3 should work without such preparation. Whether students understand technical details related to medicine is secondary in importance, as the lab is currently designed, to the realization that *different groups may feel very differently about the use of a given technology*. For this lab, it is most important that students learn that society and technology interact. Nevertheless, the following concepts may be useful within the various scenarios.

Medical Care Scenarios:

- The body is made of organs that can become damaged or diseased.
- Organs are composed of microscopic cells, whose function is similar to biological factories that produce important products like proteins.

- Blood circulates throughout the body, carrying raw materials to cells and products of the immune system, which helps fight disease.
- Disease is sometimes caused by an invasion of bacteria (single celled organisms) or viruses (DNA wrapped in a sheath of proteins).
- The average cell in the human body is 10,000 nanometers across; a red blood cell is 2,400 nanometers thick; a typical virus is 74 nanometers in diameter; a DNA helix is 2 nanometers wide

Supplemental Materials:

- Handout: Identity Sheets and Worksheets (pdf)
- Teacher's Supplement: Suggested Effects of Familiar Technologies (pdf)
- Teacher's Supplement: Possible Effects of Select Nanotechnologies (pdf)

References:

- MRSEC - http://mrsec.wisc.edu/edetc/

Authors:
IPSE Interns: Lauren Sammel, Greta Zenner

IPSE Leadership Team: Wendy C. Crone, Amy Payne, Greta Zenner, and Tom Derenne

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