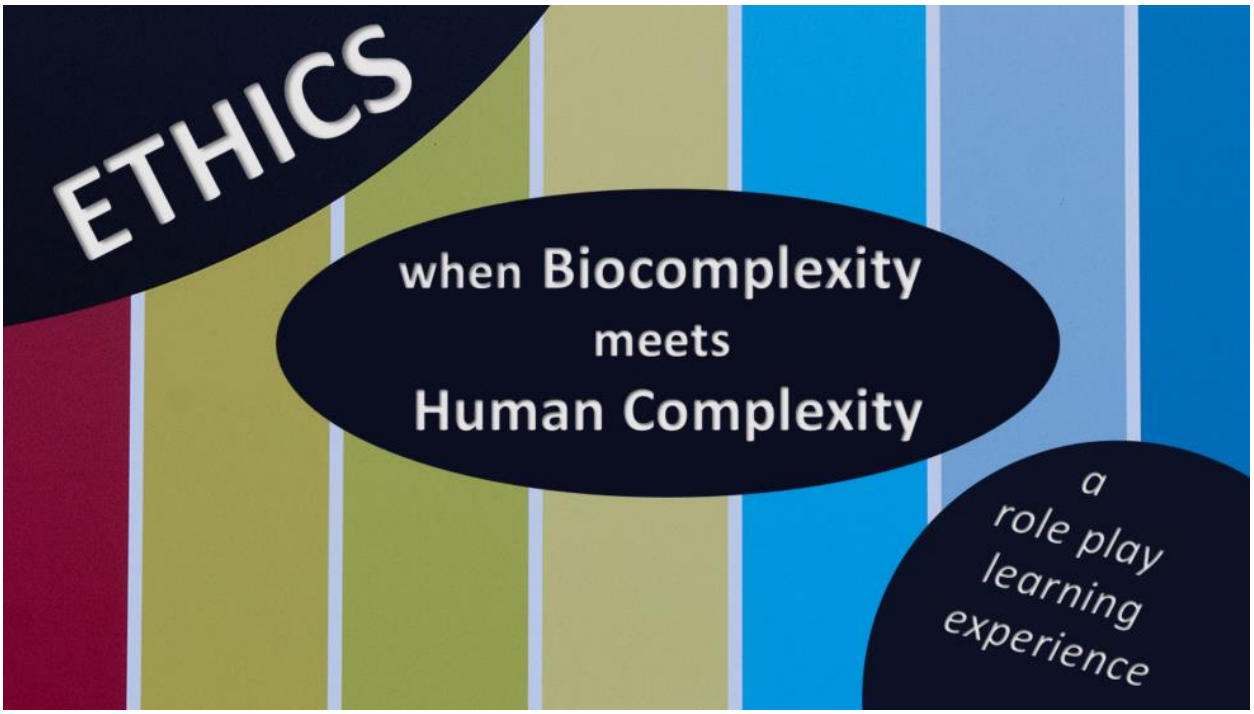


Table of Contents

Sponsored by the National Science Foundation,
Award Numbers 1338682 and 1623870

Instructor Notes for Workshop Leader

This is a role play workshop designed for ethics education of STEM graduate students. It primarily emphasizes societal-level macroethics related to decision-making related to commercial application of emerging nanotechnoloies, as opposed to microethics or responsible conduct of research (RCR). However, students will confront dilemmas at the level of individual contact through perspective-taking in acting as one of seven characters in a hypothetical, but realistic, case.

To offer the *Nanosilver Linings* case in the context of one, three-hour workshop, the basic steps are:

- Register **7** students per group. (The workshop can run with either six or seven students, allowing room for one cancellation or no-show without disrupting the role play case.) Doodle internet polling can be used for this purpose, choosing the (free) option to limit the number of participants.
- Prepare materials (copies of the *Nanosilver Linings* case, character folders including readings and private information, nametags, certificates, assessment forms)
- One week in advance, send out the set of readings (highlighted in green) intended for all participants.
- Adapt workshop slides with photos of your registered participants
- Water/coffee and baked goods may be served during the event

Requirements

- Groups of six or seven participants are required for this exercise. It is recommended that, if scheduling a free-standing workshop even, seven participants are scheduled in advance. That way, if there is a cancellation or no-show on the day of the event, the workshop can take place without need for recruiting a substitute on short notice.

Options and Flexibility

Personnel

- The character Carlson, concerned parent, may be included or excluded, allowing a ±1 extent of flexibility in number of participants per group.
- Participants may be engaged in the study of any STEM field, or field related to STEM (e.g. Philosophy of Science, Science Policy, etc.)
- Participants may be from the same, or different, fields.
- Participants may be at different levels of study; this experience was designed with STEM graduate students at any level or year of study in mind, but may also be appropriate for advanced undergraduates.
- Participants may know one another well, or not at all, prior to the workshop.

- Characters assignments may be determined by random draw, by the workshop leader, or by the participants.

Time

- Running time may be adjusted through time allotted for reading, accordingly adjusting the amount and difficulty of readings selected or assigning readings in advance.
- Electronic highlighting can be applied to readings before printout to draw out the most pertinent passages, thus reducing reading time and volume while maintaining the original document context.
- Time allotted for discussion is flexible, and can be used to adjust total running time.
- The length and nature of the break is flexible.

Content

- Selection of readings by the workshop leader allows flexibility with regard to level of difficulty.
- Selection of readings by the workshop leader allows flexibility with regard to subject matter emphasis.

Materials Checklist

- ✓ Informed consent form, if applicable
- ✓ Identical initial packets for each participant, with case plus selected readings
- ✓ Slides with character identities and student photos (prepared while participants are in common learning phase), template provided in Power Point file
- ✓ Character specific nametags
- ✓ Character specific packets, with character information and selected readings
- ✓ Discussion questions/slides (Power Point file)
- ✓ Assessment forms

Note to Instructors: When the case and workshop were composed, a number of worthy learning objectives were held in mind. Assessment data have been used identify which, of the items listed here, were indeed achieved. The learning objectives in **bold** were considered the most addressed, with cross-cohort averages between 4 and 5, where 4 is agree and 5 is strongly agree, with the statement 'Participation in this workshop increased my ability to: (specific learning objective)' (n=26). In the current student version of Nanosilver Linings below, only the bold items are included.

Explanatory text for learning objectives provided to participants:

Participation in this workshop is intended to contribute toward specific objectives for your learning. Unlike much of science and engineering education, is not intended to provide you with

specific information or technical competency you did not have before. It is an active experience relevant to your preparation to serve society as a responsible scientist or engineer.

Workshop Learning Objectives

- **Identify stakeholders in a complex decisions pertaining to science and technology.**
- **Understand how the perspectives of different stakeholders are informed and communicated.**
- Name indirect obligations and responsibilities associated with designing, making, and marketing products.
- **Appreciate the human factors, conflicts of interest, struggles, and tradeoffs in a participatory governance scenario pertaining to science and technology.**
- Comprehend the role of governance in how science and engineering are applied in the world.
- Identify value-based decisions made in the practice of evaluating emerging technologies around the product life cycle.
- Explain some ethical principles and frameworks applicable to these value-based decisions.
- **List ethical dilemmas involved in public communications about science and technology.**
- **Understand the inherent limits of quantitative, technical methods of assessment in incorporating values.**
- Relate values to the way practice, business, and policy decisions about science and technology should be made.
- Articulate an understanding of a scientist or engineer's professional rights and responsibilities relative to those of consumers and other stakeholders.
- **Operate professionally as a scientist or engineer even in 'grey areas' of practice where there is no possibility of a single correct answer.**

Flow of workshop events, Workshop Leader (with 3-hour workshop pacing information)

***Part 1* (80 minutes)**

Brief welcome statement by workshop leader, including statement about learning goals and expectations (5 minutes)

Common learning phase; Students receive background narrative, public information about all characters, article printouts to establish base of common knowledge), flow of events, and workshop guidelines; (20 minutes)

Visual display of character assignment; Workshop leader presents introductory slides, shows Power Point slide with photo of participant linked to character assigned (5 minutes)

Individual character learning phase; Students are given packets containing private information about their own characters; participants read, gather materials to quote or cite in their remarks, write opening statement for town hall meeting, prepare for directed question phase. (30 minutes)

> (If multiple cohorts of six or seven participants are run in parallel, and additional time should be allotted for participants assigned the same character to meet with one another, comparing and discussing opening statements.)

Town meeting starts with Mayor, each character delivering prepared opening statement (in character) (20 minutes)

_____Break in Workshop (10 minutes) _____

***Part 2* (90 minutes)**

Directed question phase (in character); panel consisting of Hansen, Thompson, and Brown receive questions from Green, Jones, Reed, and Carlson (15 minutes)

Conversation phase (in character); any character may direct question or comments to any other character or the group at-large (a free-form discussion) (15 minutes)

Break in character; participants as themselves; workshop leader presents discussion questions and prompts (15 minutes)

Discussion phase, students as themselves; Workshop leader presents slides including discussion questions paired with learning objectives (25 minutes)

Assessment (20 minutes)

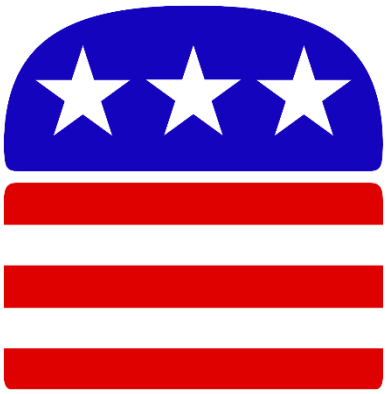
Note to Instructors: The following section contains each character's public and private information (Loui 2009), which should be distributed in each individual folder upon role assignment, along with the Guidelines for Role Play on page 15 below.

Loui, M. C. (2009). What can students learn in an extended role-play simulation on technology and society? Bulletin of Science, Technology & Society, 29(1), 37-47. doi: 10.1177/0270467608328710

You are…Hansen, NanoPackaging Solutions Executive

Public Information: Hansen is a shrewd and savvy businessperson known for toeing ethical lines when profit is involved. Before moving to NanoPackaging, Hansen worked with for a hydrofracking firm and helped them move into a city where many citizens voiced opposition and concerns about the environmental impact. Hansen sees the benefits of free market capitalism more than its downsides, holding that: citizens and businesses should concern themselves with the present time and economic viability; long-term problems can't be foreseen and other problems (with workers, wildlife, etc.) should be dealt with as they arise; it is unwise and unfair for some to 'borrow trouble' at the expense of real, tangible benefits for others. Hansen was born and raised in East Falls, but hasn't lived in the Midwest as an adult until a few months ago. NanoPackaging's need for an executive presence in East Falls coincided with a worsening family health situation requiring in-person attention.

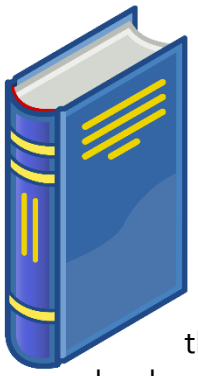
Private information: Hansen's father died recently, and in bereavement Hansen's emotions are more volatile. The cause of death was mesothelioma, a condition he contracted from a career as a construction worker. While Hansen truly believes environmental issues can be addressed along the way and tend to be overblown by 'tree-huggers', Hansen has a personal soft spot with respect to occupational health hazards and the health of the people. Hansen has also been told by an executive within NanoPackaging that the outcome in East Falls will determine Hansen's own employment status with the company. Hansen anticipates that Green will be vehement in protesting the interests of NanoPackaging, taking the moral high ground with respect to uncertain risks to human and environmental health. Hansen is prepared to counter with an ethical justification for nanotechnology-enabled food packaging—the need to reduce food waste in addressing food need for a burgeoning global population.



You are… Thompson, Mayor of East Falls

Public Information: Thompson is approaching the end of the second term as mayor and is hoping for re-election, but the current unemployment rates have dropped approval ratings considerably. Although not personally at fault for the closing of the steel mill, as time passes without new employment opportunities in the city, the citizens are taking some frustration out on the mayor. The location of NanoPackaging to East Falls would greatly increase approval ratings amongst the blue-collar middle class, who vote in droves through the organized efforts of the Unions. However, Mayor Thompson risks losing the approval of many advisors, the intellectual and financial elite of the community, many of whom represent power and influence that could define the future of Mayor Thompson's political career.

Private Information: Under the table, Thompson is being offered bribes from opposing forces; each trying to sway the Mayor to their cause. The pro-NanoPackaging contingency is offering more lucrative incentives. However, Mayor Thompson has relied heavily on the Scientific Advisory Panel when it comes to major decisions where scientific evidence is involved, and it would disrupt their working relationship to blatantly go against their advice. The mayor's scientific advisors are themselves divided as to a recommended course of action. Some are concerned that emerging nanotechnologies, both materials and processes, pose a real toxicological risk that could undo the incipient NanoPackaging company altogether. Others are more wary of the potential for public backlash, whether scientifically justified or not. They use Bisphenol A as an example that people are getting skittish about what is leaching out of their food and beverage containers. In private reflection about the future of East Falls, Thompson thinks that the best long-term strategy would be to focus on geographically fixed assets—the lake and the university—rather than a major industrial employer whose continued presence cannot be taken as a given.



You are… Professor Brown, Researcher and Instructor at a local university

Public Information: Within academic circles, Brown is a well-respected researcher with a doctorate from an Ivy League institution. In the community, Brown is known for outreach work, such as judging the science fair, and now for bringing the Great Lakes Shore Nature Preserve and STEM Education Center to town. Brown is articulate and grants interviews with the press. Nanotechnology has sparked the interest of journalists, so Brown has been trying to keep up in general, and not just in one limited area of expertise, with respect to the forefront of nanoparticle research. Professor Brown is convinced of the potential for positive applications incorporating nanomaterials but has also read research papers that give cause for thoughtful concern, and at least a modicum of restraint in action. Professor Brown feels pressure to give simple answers where the reality behind the questions is actually quite complex and partially unknown.

Private Information: At the university, Brown is under pressure. In the department, citizenship, outreach, and community education initiatives are not highly valued. With federal funding opportunities in decline, the scientists and engineers are being encouraged to collaborate with the business sector in ways that get corporate money flowing into the university. Any public remarks interpreted as anti-NanoPackaging may adversely affect Professor Brown's career at the university. The university's Board of Trustees includes the CEO of the food conglomerate contracted with NanoPackaging, who wants to see them locate to East Falls over the competing candidates.

You are…Green, Representative for the Eco Footprint Foundation, an environmental NGO

Public Information: An established environmentalist, Green worked as an ecologist studying the effects of industrial waste on aquatic environments in Lake Michigan. Green openly opposes NanoPackaging moving into town because of the unknown environmental risks of silver nanoparticles on the environment. Green refers frequently to the Precautionary Principle, saying that we should be nearly certain of safety before we introduce this new technology into society and the environment. The food dimension of this enterprise disturbs Green as well. Green is active in organic community gardening and the local foods movement—chemically enabling increased shelf life for processed food is counter to this movement, which is seen to promote public health (with respect to epidemic levels of obesity and nutritionally deficient 'food deserts') as well as ecological health.

Private information: Green is negotiating a role for Eco Footprint at the Great Lakes Shore Nature Preserve and STEM Education Center; Brown acknowledges potential for Eco Footprint to enhance the center but is expressing concern about real or perceived politicization of the center. Green wonders whether public speech related to the NanoPackaging issue will sway these negotiations. Although Green chooses to live humbly in accordance with personal values, Green's parents are financially well-off. As members of boards and Chambers of Commerce, they have expressed a strong preference that Green quiet opposition to corporate interests in public. Nonetheless, Green is determined to boldly and insistently defend the environment on behalf of the NGO, and in accordance with personal values. For a sustainable future on planet Earth, financial self-interest cannot be unopposed in shaping decisions about science and technology.

You are…Jones, Skilled worker

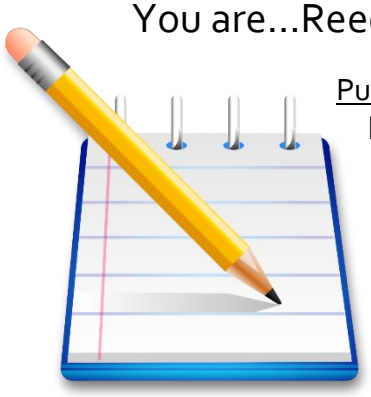
Public Information: Nearly everyone in town has heard the 'American Dream' story of Jones, since it was featured by CNN interviews as a human interest dimension of the news coverage when the steel mill announced its closure of the East Falls plant. The story starts with grandparents who changed their name to Jones upon immigrating to the United States, because they wanted to give their children and grandchildren every possible opportunity to fit in as Americans. The newly-American family ran a small ethnic grocery below the flat where they lived, guaranteeing food and shelter, though money for other things was sometimes very tight. The parents of Jones met in the public Chicago high school they attended, married at age 19, and worked tirelessly to modernize the family grocery, eventually opening a second location in East Falls with some tables for restaurant service. The steel mill employees were regular customers there, and when Jones was sixteen years old and rebelliously seeking a summer job separate from the family business, a patron saw to it that a production worker position was offered. After high school graduation, Jones continued as a production worker full time and was promoted to a production supervisor position after ten years on the job. Functioning so well as a line manager, Jones was promoted again after eight more years, to an operations manager position overseeing multiple production lines. Now Jones is still unemployed and eager to resume professional life.

Private information: Jones was just beginning to feel confident about saving enough money for college tuitions and weddings for children, and for retirement, when the news of the East Falls steel mill closure arrived. With deep family roots and a strong social network in the community, Jones does not want to relocate the family but needs to draw a salary again soon, so news of the prospect of Nano Packaging Solutions locating in East Falls seems a potential godsend. Jones is considered a shoe-in for a high level production supervisor position if NanoPackaging Solutions follows through with the local hiring process it has referred to in public statements, but the lack of detailed commitment on this point is a bit nerve wracking to Jones and the other highly skilled workers left jobless by the steel mill's departure, especially those without college degrees. If things work out and Jones does become a production supervisor for Nano Packaging Solutions, the next challenge will be to figure out how to ensure occupational safety and health protections for direct reports in the very new field of nanomanufacturing. The fact that tiny particles of metal are involved makes Jones a bit nervous, because of a workplace accident that took place in the early years of production work—maintenance on a ventilation system had been neglected by superiors, and when the system failed invisible airborne particulates landed Jones in an ambulance in severe respiratory distress. This experience has stayed in the mind of Jones over the years. With managerial authority, Jones took great pride in adhering to standards and regulations to facilitate a fair and safe working environment with no major accidents or emergency illnesses, which led to low turnover and high employee satisfaction on lines supervised by Jones. The practices of the steel industry had been refined through the decades,

compliance improved, and the dangers faced by workers were mostly visible and understood. The international standards and federal regulations about nanotechnology seem nonexistent, or rudimentary and inadequate, in comparison. After being blindsided by the closure of the steel mill, and by respiratory distress brought on by breathing invisible particles, Jones is keenly aware that the most worrying threat is an unrecognized one. Jones realizes that none of these fears can show in advocating strongly for NanoPackaging in East Falls. Jones hopes that nobody publicly recalls the details of the workman's compensation case of long ago in order to weaken the argument that NanoPackaging would be a boon for the workers of East Falls. Invisible particles or not, high tech seems to be the future of manufacturing all over America, and Jones wants to go back to work in East Falls…NanoPackaging is the only hope on the horizon, and it has to be fought for.

Acknowledgement: The authors thank Christopher Bosso, Ph.D. for insightful contributions to the development of character Jones.

You are…Reed, Investigative journalist



Public Information: Reed is a well-known investigative journalist who has been involved in unravelling numerous scandals, including unethical business practices, in the greater Chicago area. Reed is not formally educated in science, engineering, or business. However, Reed does all of the homework necessary to pursue journalism at an elite level. For this story, Reed has conversed with enough experts and read/understood enough about nanoscience to have a much better grasp of the material than the average citizen. Reed intends to ask pointed, detailed questions about the size of nanosilver particles being used, the migration rates of silver ions or nanoparticles into foods from NanoPackaging containers, and the environmental fate and persistence of silver from packaging after end-of-life disposal.

Private Information: Reed chose a career in investigative journalism before the internet era, and wonders about job security despite producing excellent work. For this assignment, Reed's editor has tasked Reed with uncovering as much dirt on NanoPackaging Solutions as possible in order to create a more enticing story for readers (and thus advertisers). Because of this, Reed is forced to be less-than-balanced in questioning of Hansen, Brown, and Thompson even though personally sympathetic with the cause of an economically beleaguered town attempting to gain job opportunities. Reed's father has provided an earful on the subject of NanoPackaging and East Falls. Before retiring, Reed's father spent an entire career on the factory floors of East Falls, alongside his brother. Reed's uncle recently passed away due to mesothelioma, something their family blames the scientific and industrial communities for because they rushed forward with a technology before understanding the occupational health risks of it. Reed's dad is grieving, concerned about his own occupational exposures, and laments the harmful consequences of the rapid technological change he's seen throughout his life. The interaction between Reed and Hansen is complicated by the fact that Reed's father and uncle worked briefly with Hansen's father and knows that he died of mesothelioma as well.

You are…Carlson, Concerned parent

Public Information: Carlson is known as an active parent in the community's public schools, sometimes working as a substitute elementary school teacher, as well as in community affairs. Carlson has recently recovered from melanoma, and this health scare has led Carlson to conduct internet research into the efficacy of different sunscreens. There are numerous articles about the presence of metal nanoparticles in sunscreens, which led Carlson to discover information, misinformation, and hype about nanotechnology in general.

Private Knowledge: Carlson's spouse was laid off when the steel mill closed and has yet to find any work. Ultimately Carlson secretly wants the end result to be for the NanoPackaging company to move into town. Carlson wants their family and other families in their community to have the opportunity to provide for their families through adequate work without needing to relocate. That said, Carlson's own work and the education of the family's children depends upon the public school system—Carlson does not want jobs to come to the city at the expense of the schools. Also, health is now a deeply personal concern, with any mention of carcinogens or cancer triggering fear.

Guidelines for Role Play

1. Once in character, stay in character

It can be tempting to remark in your own voice (e.g. "Based on everything I know, I'm having a really hard time deciding what my character would say…") but please resist any urge to break character until notified by the workshop leader.

2. Maintain consistency with character

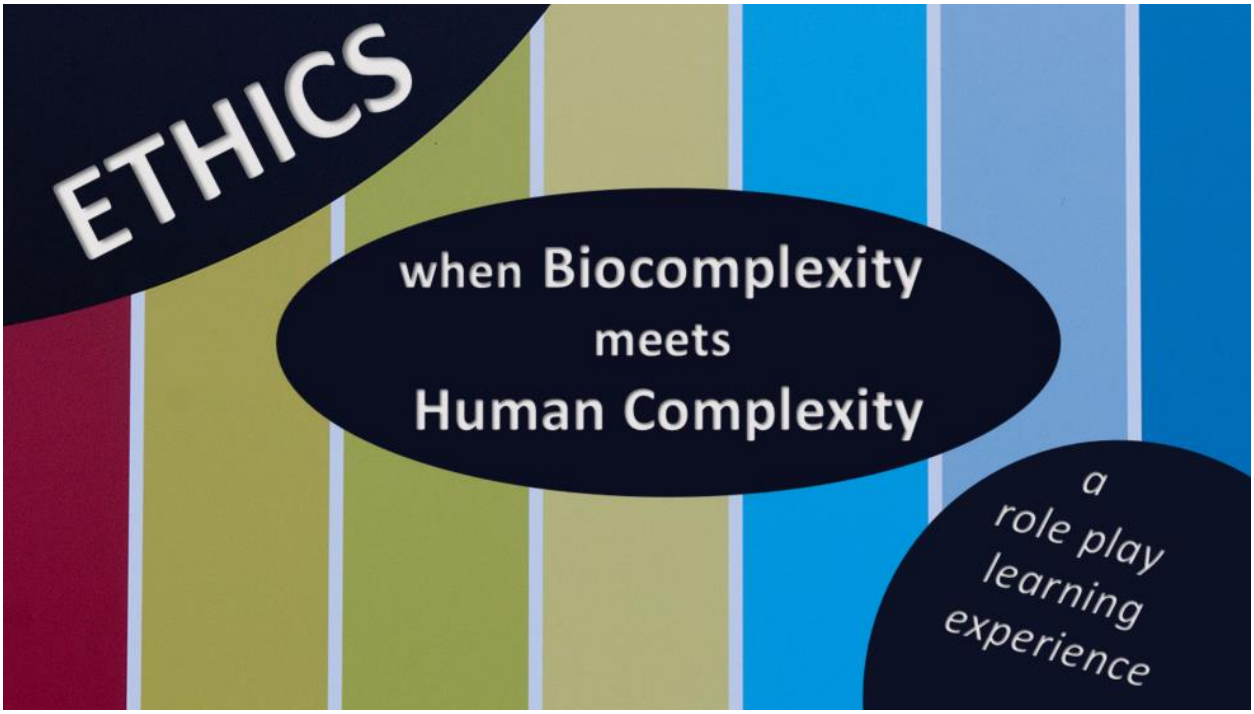
If the character you were assigned seems quite dissimilar to you, it may be challenging to refrain from displaying your own knowledge and values in the guise of your character. Please do your best to put yourself in the shoes of this character and act accordingly. Remember that you will have the opportunity to reveal your own thoughts and feelings, and how they differ from those of your character, during the discussion phase.

3. Make choices and be creative without hesitation

As the characters have been defined, there are many different emphases and tactics consistent with each one. There is no one 'right' way to play a given character. You will make choices as you go, and all are valid as long as you maintain consistency with the character as defined.

4. Relax, enjoy, and learn

Rigidity, self-consciousness and self-critical inner dialogue may be habits of mind you've adopted because they propel you toward excellence in many academic tasks…but in this case, they will be counter-productive, for both your own learning and for the learning of other participants.



Principal Investigator, Kathleen Eggleson keggleso@nd.edu

Additional References and Suggested Readings, Background/All Characters

(Note to Instructors: Highlighted texts are lead candidates for distribution to all participants one week prior to workshop.)

Nanosilver and Society

Landsdown, A.B.G. (2006) Silver in health care: antimicrobial effects in safety and use. Current Problems in Dermatology 33:17-34.

Seltenrich, N. (2013) Nanosilver: Weighing the Risks and Benefits. *Environmental Health Perspectives* 121(7):A220-A225

Nanosilver and Life Cycle Assessment

Walser, T., Demou, E., Lang, D.J., and Hellweg, S. (2011) Prospective Environmental Life Cycle Assessment of Nanosilver T-Shirts. *Envrionmental Science and Technology* 45:4570-4578.

Nanosilver and Food Packaging

Echegoyen, Y. and Nerin, C. (2013) Nanoparticle release from nano-silver antimicrobial food containers. *Food and Chemical Toxicology* 62:16-22.

Background: Relevant News

Wines, M. (2014) E.P.A. Unveils Second Phase of Plan to Reverse Great Lakes Damage. *New York Times*, September 24. http://www.nytimes.com/2014/09/25/us/epa-unveils-plan-to-restore-great-lakes.html

Additional References and Suggested Readings, by Character

(Note: Highlighted texts are lead candidates for distribution to individual characters in packets distributed upon character assignment.)

Hansen

Hansen reads periodicals avidly, such as *The Wall Street Journal, Forbes, Bloomberg,* and *Fortune.*

Buzby, J.C. (2010) Nanotechnology for Food Applications: More Questions than Answers. *The Journal of Consumer Affairs* 44(3):528-545.

Enis, M. (2012) Small Change: Nanotechnology in Food Packaging. *Supermarket News*, January 23.

Sozer, N. and Kokini, J.L. (2010) Applications of Nanotechnology in the Food Industry. Food Engineering & Ingredients, 35(1):12-15.

Whitefoot, K.S. and Valdivia, W.D. (2015) Innovation and Manufacturing Labor: A Value-Chain Perspective, Paper of the Center for Technology Innovation at Brookings

A Little Risky Business—The Risk in Nanotechnology. *The Economist* (US), November 24, 2007.

Map of manufacturing data by state and year recommended for Hansen, Jones, and Thompson; available online at http://trade.gov/manufactureamerica/facts/tg_mana_003019.asp Prepared by: Office of Trade and Industry Information, International Trade Administration, Source: Bureau of Economic Analysis, U.S. Department of Commerce

Thompson

Sargent, J.F. (2013) *Nanotechnology: A Policy Primer*. Congressional Research Service Report for Congress.

One of Thompson's advisors from the university sent this article:

Kearnes, M. and Wynne, B. (2007) On Nanotechnology and Ambivalence: The Politics of Enthusiasm. *NanoEthics* 1:131-142.

Map of manufacturing data by state and year recommended for Hansen, Jones, and Thompson; available online at http://trade.gov/manufactureamerica/facts/tg_mana_003019.asp Prepared

by: Office of Trade and Industry Information, International Trade Administration, Source: Bureau of Economic Analysis, U.S. Department of Commerce

On the internet, the Mayor has been reading about Bisphenol A on the advice of the scientific advisory board with an eye on policy and regulatory issues at http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/bpa.html. The mayor is looking at the tax abatement incentives other cities are offering at http://www.houstontx.gov/ecodev/abatements.html, http://www.indy.gov/eGov/City/DMD/ED/New_Expanding/Tax_Abatement/Pages/home.aspx, and https://www.stlouis-mo.gov/government/departments/sldc/economic-development/financing/real-estate-tax-abatement.cfm, among others. What the mayor knows about nanotechnology came from http://nano.gov/.

Brown

Professor Brown has been reading articles in the peer-reviewed academic literature, as listed above (e.g. Artiaga et al 2015, Handford et al 2014, Walser et al 2011, Kumar et al 2014, Echegoyen and Nerin 2013), and others:

Browning, L.M., Lee, K.J., Nallathamby, P.D., and Xu, X-H.N. (2013) Silver Nanoparticles Incite Size- and Dose-Dependent Developmental Phenotypes and Nanotoxicity in Zebrafish Embryos. *Chemical Research in Toxicology* 26:1503-1513.

Sections 1 and 3 of Duncan 2011 (above)

McShan al. 2014 (above)

Brown has also seen Luoma 2008:

Luoma, S.N. (2008) *Silver Nanotechnologies and the Environment: Old Problems or New Challenges?*, Report of Woodrow Wilson International Center for Scholars Project on Emerging Nanotechnologies

Green

Green has been reading NGO reports:

Behar, A., Fugere, D., and Passoff, M. (2013) *Slipping Through the Cracks: An Issue Brief on Nanomaterials in Food*, Report of As You Sow.

Illuminato, I. (2014) *Tiny Ingredients Big Risks: Nanomaterials Rapidly Entering Food and Farming*, Report of Friends of the Earth United States.

Senjen, R. and Illuminato, I. (2009) *Nano and Biocidal Silver*. Report of Friends of the Earth Australia and Friends of the Earth United States

Green has also seen Luoma 2008 (above)

Jones

International Trade Administration, United States Department of Commerce. (2010)The State of Manufacturing in the United States, http://trade.gov/manufactureamerica/facts/tg_mana_003019.asp

Tomczyk, M. (2014) *NanoInnovation: What Every Manager Needs to Know (2nd Edition)*. Weinheim:Wiley, pages 1-54.

Map of manufacturing data by state and year recommended for Hansen, Jones, and Thompson; available online at http://trade.gov/manufactureamerica/facts/tg_mana_003019.asp Prepared by: Office of Trade and Industry Information, International Trade Administration, Source: Bureau of Economic Analysis, U.S. Department of Commerce

Reed

Seltenrich 2013 (above)

Behar, A., Fugere, D., and Passoff, M. (2013) *Slipping Through the Cracks: An Issue Brief on Nanomaterials in Food*, Report of As You Sow.

Luoma 2008 (above)

NIOSH publications about nanotechnology: http://www.cdc.gov/niosh/topics/nanotech/

A Little Risky Business—The Risk in Nanotechnology. *The Economist* (US), November 24, 2007.

Wines, M. (2014) E.P.A. Unveils Second Phase of Plan to Reverse Great Lakes Damage. *New York Times*, September 24. http://www.nytimes.com/2014/09/25/us/epa-unveils-plan-to-restore-great-lakes.html

Carlson

National Education Association (2003) *Protecting Public Education from Tax Giveaways to Corporations*, Research Working Paper of National Education Association

Senjen, R. and Illuminato, I. (2009) *Nano and Biocidal Silver*. Report of Friends of the Earth Australia and Friends of the Earth United States

On the internet, Carlson has been reading about tax abatements and schools at http://www.goodjobsfirst.org/accountable-development/key-reforms-protecting-schools. On sunscreens, one of resources that makes the most sense to Carlson is a video:

http://youtu.be/VVocCg4clMw. One of Carlson's friends from a cancer support group sent a link about food packaging and cancer: http://www.dailymail.co.uk/health/article-2684256/Dangerous-chemicals-food-packaging-linked-cancer-fertility-birth-defects-study-finds.html.

(Note: Yellow highlighting indicates distribution in character folders in the initial offerings of the workshop.)

Note to Instructors: If the *Nanosilver Linings* role play experience is being incorporated into a course rather than as a stand-alone workshop, additional readings approaching the topic of nanosilver in food packaging from around the product life cycle may benefit student learning. Suggestions for life cycle stage-based readings are included below.

Additional References and Suggested Readings, by Life Cycle Stage

Life Cycle Stages: Supply and Manufacture (Occupational Health)

Bachand, G.D., Allen, A., Bachand, M., Achyuthan, K.E., Seagrave, J.C., Brozik, S.M. (2012) Cytotoxicity and inflammation in human alveolar epithelial cells following exposure to occupational levels of gold and silver nanoparticles. *Journal of Nanoparticle Research* 14:1212.

Chaudhry, Q., Scotter, M., Blackburn, J., Ross, B., Boxall, A., Castle, L., Aitken, R., and Watkins, R. (2008) Applications and Implications of Nanotechnologies for the Food Sector. Food Additives and Contaminants 25(3):241-258.

Map of manufacturing data by state and year recommended for Hansen, Jones, and Thompson; available online at http://trade.gov/manufactureamerica/facts/tg_mana_003019.asp Prepared by: Office of Trade and Industry Information, International Trade Administration, Source: Bureau of Economic Analysis, U.S. Department of Commerce

Life Cycle Stage: Storage, Package, Distribution (Product Behavior, Shelf Life, and Transportation)

Artiaga, G., Ramos, K., Cámara, C., Gómez-Gómez, M. (2015) Migration and characterization of nanosilver from food containers by AF4-ICP-MS. *Food Chemistry* 166(1):76-85.

Duncan, T.V. (2011) Applications of nanotechnology in food packaging and food safety: Barrier materials, antimicrobials and sensors. *Journal of Colloid and Interface Science* 363(1):1-24.

Echegoyen and Nerin 2013 (above)

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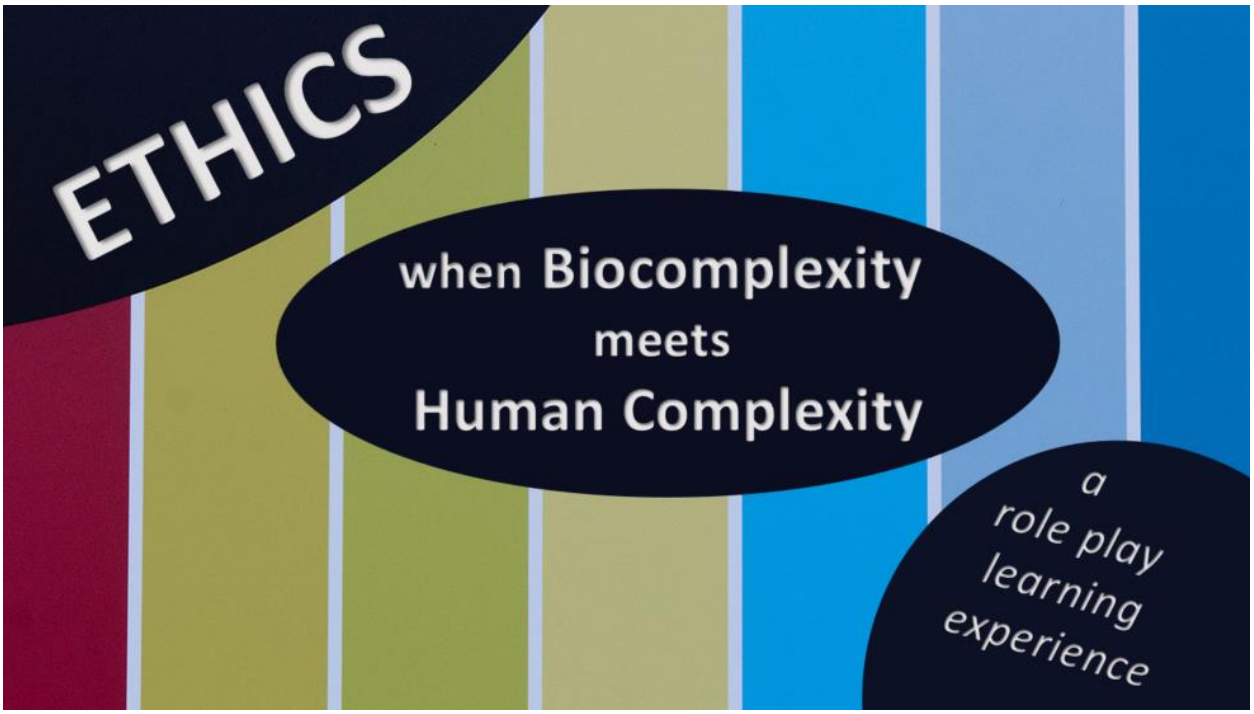


Nanosilver Linings

Case Authors: Kathleen Eggleson, Ph.D. (Principal Investigator)
& Joshua Dempsey (Undergraduate Research Fellow)

You will be participating in a workshop including role play in fictitious scenario based upon real science, technology, and human behavior. The scene is set in the fictitious city of East Falls, Indiana. You will play the role of one of six or seven characters who are stakeholders in the outcome of collective decision making. Each of the characters has a distinct role in the community, with differing educational backgrounds, motivations, and personal influences; but all will attempt to interact productively around a potential reality—the location of a food

packaging business incorporating nanosilver, and perhaps other emerging nanotechnologies relevant to food packaging—to their home city, East Falls.

East Falls is a city located in northwestern Indiana. For years, the city's economy has thrived on jobs created by the local steel mill and related businesses. A year ago, the steel company officially closed, succumbing to international competition. Unemployment in East Falls has reached 10% and the pressure on government officials to find a solution is very high. One victory in restoring economic viability to the city has been recently announced: there will be a Great Lakes Shore Nature Preserve and STEM Education Center opening in an abandoned building on the lakeshore. It represents a public-private partnership involving the city of East Falls, Lakeshore University (Professor Brown, Principal Investigator), and the National Science Foundation. Although the number of jobs directly created is modest, many in town hope that the Great Lakes Shore Center will draw visitors, stimulating the local economy with tourism revenue.

NanoPackaging Solutions, a company specializing in functionalized food packaging, wishes to move into East Falls and build research and development laboratories as well as factories to produce their finished products. Their initial line of finished products will feature nanosilver, which offers potent antimicrobial action. Their R&D plans to partner with the scientists and engineers at Lakeshore University to stay on the leading edge of advances in materials science and nanotechnology relevant to food packaging so that the company can deliver even more features and functions in future product lines. NanoPackaging Solutions thinks that East Falls is a viable location because of its proximity to Midwestern agriculture and the markets of Chicago, Indianapolis, Cleveland, Columbus, and Cincinnati. The move into East Falls would create a multitude of jobs ideal for the blue collar populace of East Falls, as well as graduates and postdocs from the university.

NanoPackaging's first product line, for which they already have a contract with a major US food conglomerate, will include three product types containing nanosilver: resealable bags, waxy coatings for fruits and cheeses, and lined plastic storage containers. The waxy coating contains nanoparticles between 5nm-10nm in size; the resealable bags use AgNPs around 40nm in size, and the plastic storage containers contain AgNP between 10-20nm. The nanoparticles for each product are engineered to maximize the efficacy of the antimicrobial properties of the respective product. Shelf lives of products are markedly longer than their counterparts without nanosilver; peer-reviewed research and extensive product testing supports these claims.

Nanosilver is known for its antimicrobial properties and is used in many commercial products. While many of the benefits of nanosilver are known, knowledge of the risks of nanosilver is limited due to lack of information and research. Citizens are anxious about getting back to work, but a few inhabitants of East Falls are concerned about occupational and environmental hazards of nanosilver. One major opponent of NanoSilver Packaging Solutions is The Eco Footprint Foundation.

The Eco Footprint Foundation is an Environmental NGO which works extensively in states adjacent to Lake Michigan, primarily Indiana, Michigan, Wisconsin, and the Chicago area. Much of their work encompasses environmental campaigns against aquatic pollution of Lake Michigan due to industrial wastes. They have worked extensively with pollution control in Chicago as well as kickstarted a Lakefront Cleanup initiative along the coast of Wisconsin. The Indiana division of the Eco Footprint Foundation works primarily with pollution and environmental beautification of the southeastern reaches of the greater Chicago area. They also look into effects of pollutants on soil, particularly as it applies to the rich farmlands of Indiana and Illinois. The Eco Footprint Foundation is strongly opposed to the introduction of NanoPacking Solutions into East Falls because the long-term effects of nanosilver waste products on the environment is not understood, and

the evidence on acute aquatic, biomedical, and soil toxicity is suggestive but mixed. They do not want another environmental mishap, such as the DDT saga, to unravel again, and they doubt that the regulatory structure in place now is sufficient to prevent one.

A town meeting has been called because city law requires an open forum deliberation when changes or exceptions to tax policy are in question. NanoPackaging Solutions has been offered a set of abatements by another candidate location, and has made it clear to the Mayor that their location to East Falls hinges on offering of a competitive set of abatements. The decision on whether these tax abatements are granted is, in effect, a decision about whether NanoPackaging will establish itself in East Falls or the competing candidate city. Today, citizens will hear expert testimony from the academic, business, government, and NGO sectors on why or why not the food packaging company should be offered tax deferral incentives to establish itself in East Falls, and, if it does move into town, what regulatory measures would protect occupational safety, public health, and environmental well-being. As befitting a democracy, individual citizens will also have the opportunity to voice their positions and concerns.

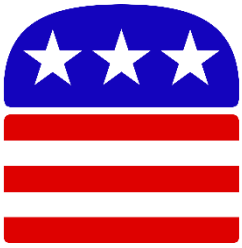
Meet the Characters

Each character is an adult citizen of East Falls, a prominent member of the community known to others as a leader of a particular organization or group of stakeholders, and may be female or male. None are related to one another by blood.

Hansen: Industry Executive

Public Information: Hansen is a shrewd and savvy businessperson known for toeing ethical lines when profit is involved. Before moving to NanoPackaging, Hansen worked with for a hydrofracking firm and helped them move into a city where many citizens voiced opposition and concerns about the environmental impact. Hansen sees the benefits of free market capitalism more than its downsides, holding that: citizens and businesses should concern themselves with the present time and economic viability; long-term problems can't be foreseen

and other problems (with workers, wildlife, etc.) should be dealt with as they arise; it is unwise and unfair for some to 'borrow trouble' at the expense of real, tangible benefits for others. Hansen was born and raised in East Falls, but hasn't lived in the Midwest as an adult until a few months ago. NanoPackaging's need for an executive presence in East Falls coincided with a worsening family health situation requiring in-person attention.



Thompson: Mayor of East Falls

Public Information: Thompson is approaching the end of the second term as mayor and is hoping for re-election, but the current unemployment rates have dropped approval ratings considerably. Although not personally at fault for the closing of the steel mill, as time passes without new employment opportunities in the city, the citizens are taking some frustration out on the mayor. The location of NanoPackaging to East Falls would greatly increase approval ratings amongst the blue-collar middle class, who vote in droves through the organized efforts of the Unions. However, Mayor Thompson risks losing the approval of many advisors, the intellectual and financial elite of the community, many of whom represent power and influence that could define the future of Mayor Thompson's political career.

Professor Brown: University Researcher and Instructor

Public Information: Within academic circles, Brown is a well-respected researcher with a doctorate from an Ivy League institution. In the community, Brown is known for outreach work, such as judging the science fair, and now for bringing the Great Lakes Shore Nature Preserve and STEM Education Center to town. Brown is articulate and grants interviews with the press. Nanotechnology has sparked the interest of journalists, so Brown has been trying to keep up in general, and not just in one limited area of expertise, with respect to the forefront of nanoparticle research. Professor Brown is convinced of the potential for positive applications incorporating nanomaterials but has also read research papers that give cause for thoughtful concern, and at least a modicum of

restraint in action. Professor Brown feels pressure to give simple answers where the reality behind the questions is actually quite complex and partially unknown.

Green: Environmental NGO Representative

Public Information: An established environmentalist, Green worked as an ecologist studying the effects of industrial waste on aquatic environments in Lake Michigan. Green openly opposes NanoPackaging moving into town because of the unknown environmental risks of silver nanoparticles on the environment. Green refers frequently to the Precautionary Principle, saying that we should be nearly certain of safety before we introduce this new technology into society and the environment. The food dimension of this enterprise disturbs Green as well. Green is active in organic community gardening and the local foods movement—chemically enabling increased shelf life for processed food is counter to this movement, which is seen to promote public health (with respect to epidemic levels of obesity and nutritionally deficient 'food deserts') as well as ecological health.

Jones: Skilled worker

Public Information: Nearly everyone in town has heard the 'American Dream' story of Jones, since it was featured by CNN interviews as a human interest dimension of the news coverage when the steel mill announced its closure of the East Falls plant. The story starts with grandparents who changed their name to Jones upon immigrating to the United States, because they wanted to give their children and grandchildren every possible opportunity to fit in as Americans. The newly-American family ran a small ethnic grocery below the flat where they lived, guaranteeing food and shelter, though money for other things was sometimes very tight. The parents of Jones met in the public Chicago high school they attended, married at age 19, and worked tirelessly to modernize the family grocery, eventually opening a second location in East Falls with some tables for restaurant service. The steel mill employees were regular customers there, and when Jones was sixteen years old and rebelliously seeking a summer job separate from the

family business, a patron saw to it that a production worker position was offered. After high school graduation, Jones continued as a production worker full time and was promoted to a production supervisor position after ten years on the job. Functioning so well as a line manager, Jones was promoted again after eight more years, to an operations manager position overseeing multiple production lines. Now Jones is still unemployed and eager to resume professional life.

Reed: Investigative journalist

Public Information: Reed is a well-known investigative journalist who has been involved in unravelling numerous scandals, including unethical business practices, in the greater Chicago area. Reed is not formally educated in science, engineering, or business. However, Reed does all of the homework necessary to pursue journalism at an elite level. For this story, Reed has conversed with enough experts and read/understood enough about nanoscience to have a much better grasp of the material than the average citizen. Reed intends to ask pointed, detailed questions about the size of nanosilver particles being used, the migration rates of silver ions or nanoparticles into foods from NanoPackaging containers, and the environmental fate and persistence of silver from packaging after end-of-life disposal.

Carlson: Concerned parent (Included if there are seven participants in the workshop. If only six participants are available, this character may be omitted.)

Public Information: Carlson is known as an active parent in the community's public schools, sometimes working as a substitute elementary school teacher, as well as in community affairs. Carlson has recently recovered from melanoma, and this health scare has led Carlson to conduct internet research into the efficacy of different sunscreens. There are numerous articles about the presence of metal nanoparticles in sunscreens, which led Carlson to discover information, misinformation, and hype about nanotechnology in general.

Flow of workshop events

Part 1

- *Welcome*
- *Common learning phase*
- *Visual display of character assignment*
- *Individual character learning phase*, preparation of opening statement
- *Town meeting* starts with Mayor, each character delivering prepared opening statement (in character)

_____Break in Workshop_____

Part 2

- *Directed question phase* (in character); panel consisting of Hansen, Thompson, and Brown receive questions from Green, Jones, Reed, and Carlson
- *Conversation phase* (in character); any character may direct question or comments to any other character or the group at-large (a free-form discussion)
- *Break in character*; workshop leader presents discussion questions and prompts
- *Discussion phase*, students as themselves
- *Assessment*

Learning Objectives

Participation in this workshop is intended to contribute toward specific objectives for your learning. Unlike much of science and engineering education, is not intended to provide you with specific information or technical competency you did not have before. It is an active experience relevant to your preparation to serve society as a responsible scientist or engineer. Specifically, your participation should increase your ability to:

- Identify stakeholders in a complex decisions pertaining to science and technology.
- Understand how the perspectives of different stakeholders are informed and communicated.
- Appreciate the human factors, conflicts of interest, struggles, and tradeoffs in a participatory governance scenario pertaining to science and technology.
- List ethical dilemmas involved in public communications about science and technology.
- Understand the inherent limits of quantitative, technical methods of assessment in incorporating values.
- Operate professionally as a scientist or engineer even in 'grey areas' of practice where there is no possibility of a single correct answer.

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Workshop Assessment, as administered to initial cohorts at the University of Notre Dame

Your feedback is very important to us, and we thank you for taking the time to complete this questionnaire.

We would like to know whether you think this learning experience achieved the stated learning objectives. On a scale of one to five, where one is strongly disagree and five is strongly agree, please indicate your level of agreement with the following items.

My participation in this workshop increased my ability to:

	1=strongly disagree	2=disagree	3=neither agree nor disagree	4=agree	5=strongly agree
Identify stakeholders in a complex decisions pertaining to science and technology.	1	2	3	4	5
Understand how the perspectives of different stakeholders are informed and communicated.	1	2	3	4	5

	1=strongly disagree	2=disagree	3=neither agree nor disagree	4=agree	5=strongly agree
Name indirect obligations and responsibilities associated with designing, making, and marketing products.	1	2	3	4	5
Appreciate the human factors, conflicts of interest, struggles, and tradeoffs in a participatory governance scenario pertaining to science and technology.	1	2	3	4	5
Comprehend the role of governance in how science and engineering are applied in the world.	1	2	3	4	5
Identify value-based decisions made in the practice of evaluating emerging technologies around the product life cycle.	1	2	3	4	5

	1=strongly disagree	2=disagree	3=neither agree nor disagree	4=agree	5=strongly agree
Explain some ethical principles and frameworks applicable to these value-based decisions.	1	2	3	4	5
List ethical dilemmas involved in public communications about science and technology.	1	2	3	4	5
Understand the inherent limits of quantitative, technical methods of assessment in incorporating values.	1	2	3	4	5
Relate values to the way practice, business, and policy decisions about science and technology should be made.	1	2	3	4	5

	1=strongly disagree	2=disagree	3=neither agree nor disagree	4=agree	5=strongly agree
Articulate an understanding of a scientist or engineer's professional rights and responsibilities relative to those of consumers and other stakeholders.	1	2	3	4	5
Operate professionally as a scientist or engineer even in 'grey areas' of practice where there is no possibility of a single correct answer.	1	2	3	4	5

Of all of individual the learning objectives, we would like to know which were **most** addressed through your participation in the workshop. Please mark the box beside the objectives (up to 3) you think were most addressed:

Learning objective	[X] for **most** addressed (select up to 3)
Identify stakeholders in a complex decisions pertaining to science and technology.	
Understand how the perspectives of different stakeholders are informed and communicated.	
Name indirect obligations and responsibilities associated with designing, making, and marketing products.	
Appreciate the human factors, conflicts of interest, struggles, and tradeoffs in a participatory governance scenario pertaining to science and technology.	
Comprehend the role of governance in how science and engineering are applied in the world.	
Identify value-based decisions made in the practice of evaluating emerging technologies around the product life cycle.	
Explain some ethical principles and frameworks applicable to these value-based decisions.	
List ethical dilemmas involved in public communications about science and technology.	
Understand the inherent limits of quantitative, technical methods of assessment in incorporating values.	
Relate values to the way practice, business, and policy decisions about science and technology should be made.	
Articulate an understanding of a scientist or engineer's professional rights and responsibilities relative to those of consumers and other stakeholders.	
Operate professionally as a scientist or engineer even in 'grey areas' of practice where there is no possibility of a single correct answer.	

Now, we would like to learn more about your experience of the workshop. On a scale of one to five, where one is strongly disagree and five is strongly agree, please indicate your level of agreement with the following items.

	1=strongly disagree	2=disagree	3=neither agree nor disagree	4=agree	5=strongly agree
This experience was a good use of my time.	1	2	3	4	5
This experience made me more prepared for 'real world' practice of science or engineering.	1	2	3	4	5
This experience was a challenge for me.	1	2	3	4	5
I will probably remember this experience for a long time.	1	2	3	4	5
I will probably recall this experience when I engage with stakeholders in the future.	1	2	3	4	5
This experience makes me more aware of my own values as they pertain to science and engineering applications.	1	2	3	4	5
This experience makes me more aware of the values of other people as they pertain to science and engineering applications.	1	2	3	4	5

	1=strongly disagree	2=disagree	3=neither agree nor disagree	4=agree	5=strongly agree
I would recommend this experience to other STEM graduate students.	1	2	3	4	5

Now, we would like to ask about your satisfaction with different aspects of the workshop. On a scale of one to five, where one is highly dissatisfied and five is highly satisfied, please indicate your level of satisfaction with the following items.

	1=highly dissatisfied	2=dissatisfied	3=neither satisfied nor dissatisfied	4=satisfied	5=highly satisfied
Quality of readings	1	2	3	4	5
Appropriateness of readings for character	1	2	3	4	5
Quality of discussion	1	2	3	4	5
Length of discussion	1	2	3	4	5
The level of detail in the hypothetical case	1	2	3	4	5
The realism of the hypothetical case	1	2	3	4	5
The workshop leader's performance	1	2	3	4	5
The way I performed in this situation	1	2	3	4	5
The way the other students performed in this situation	1	2	3	4	5

What was the most surprising thing you learned from the workshop?

What event during the workshop changed your thinking? In what way did your thinking change?

To what extent did your own character seem to you like a real, complex person rather than a caricature or archetype? To what extent did the other characters seem to you like a real, complex person rather than a caricature or archetype?

What do you want to learn more about?

Do you have any suggestions for how this workshop could be improved?

Does your thesis mentor or another faculty member in your program know you participated in this workshop?

Yes *No*

If yes, how would you characterize the level of encouragement you received?

Are there any other thoughts you would like to share?

Finally, please provide the following information.

Today's date:

Before today, how well did you know at least one other participant?

Very well (friends, labmates) *A little* (someone I've seen or know the name of) *Not at all*

The character I played was: *Brown* *Carlson* *Green* *Hansen*
Jones *Thompson* *Reed*

I consider myself: *an engineer* *a scientist*

The degree I am pursuing is: *Masters (M.S.)* *Doctoral (Ph.D.)*

The name of my program of study is:

The name of my academic department is:

What is your gender? *Male* *Female*

What is your age in years?

What is your country of origin?

With which racial or ethnic group(s) do you identify?

This is an example of the certificate presented to participants upon completion of the workshop and assessment.

This is an example of the labels, used for nametags and on the folder for each character. They are printed with Avery 5395.