The Global Impact of Design and Innovation

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Abstract

Introduction to social, cultural, environmental, and economic considerations required to innovate in today's global workforce. Students will build awareness of the impact of new innovations on society and will explore the importance of designing in ways that is accountable to the people while also being ecologically sound and socially just. Emphasis will be placed increasing awareness of the importance of equity in design with the intent of building a more diverse workforce.

Instructor notes and a PowerPoint presentation are included for working with the students.

Module Objectives

At the end of this unit, should will be able to:

- Explain the relationship between creativity, invention, and innovation.
- Explain the social responsibilities of innovators, engineers, and designers.
- Identify social, cultural, environmental, economic impacts on design and engineering.
- Investigate potential impacts of a design and/or innovation on society.
- Discuss the impact of diversifying the workforce on innovation in design.

Module Data

Key words: Innovation, engineering, design, impact, social responsibility, diversity

Pre-requisites: Students should have a basic understanding of the following terms: engineering, design, innovation, impact.

Type: Classroom lesson; discussion

Target Grade Level: Grade 11 & above

Type of Module: Classroom lesson; discussion

Time Required: 7-10 hours (Readings, Slide Deck, Class Activities)

Note to Instructors:

This Module is intended to provide students with an opportunity to investigate, discuss, and reflect on the social impact of engineering and design on society. After a brief introduction to key terminology and overarching concepts, the students will work in teams on a series of activities centered around a case study. The activities are fairly open-ended and benefit greatly from a culminating larger group discussion. Cultivating engaging discussions can sometimes be challenging, especially for faculty new to these topics. The authors suggest starting with the discussion questions/prompts provided while maintaining a willingness to veer in a different direction as the conversation and questions dictate.

The authors have found that the required readings/media provide some interesting and relevant context and, when completed prior to the Module, enable students to show up ready to engage in discussion. The Module is designed assuming these readings/media are completed as homework prior to class discussion. Alternatively, students can be given in-class time to complete the required readings/media though it would increase Module time to completion by 1-2 hours.

A comment on terminology: There is some overlap in terminology related to topics such as social justice, responsible innovation, and impact. Extensive consideration of social justice in design

and innovation is an emerging focus for engineering and use of language to describe these topics and their integration into design is still evolving. As we work to integrate social justice more deeply into the work of engineering, we also are working to develop a common language.

For additional instructor notes refer to Responsible Innovation Class Activities – Instructor Notes document.

Instructor Resources:

- Book Chapter: Professional Social Responsibility in Engineering by Angela Bielefeldt (2018). This reading describes the importance of considering social justice and diversity as part of the social responsibility of engineers.
- Article: Why Should I Care About Diversity in Engineering? from *National Society of Professional Engineers* focuses on the importance of diversifying the engineering workforce and answers some commonly asked questions.

Module Procedure:

General Outline:

1. **Required Readings/Media:** Students will complete required readings/media prior to the start of the Module.
2. **Presentation:** Instructors will present material in the provided PowerPoint to familiarize students with key terms, definitions, and other content to support their learning. The slide deck includes questions that target student comprehension of the required readings/media.
   The PowerPoint can be downloaded from the Resource section: Global Impact of Design & Innovation.
3. **Class Activities:** Students will complete the *Socially Responsible Innovation* class activity. Note that this is divided into 4 segments as shown in the table below. Each segment includes team-based activities and follow up discussion questions. Instructors can teach the segments over the course of days, weeks, or months as their schedule allows.

Segment	Description	Approx. Time
1 – Explore an Innovation	Students will research a current innovation. Includes optional "share out" with the class in presentation form.	1-2 hours
2 – Investigate Impact	Students list both positive and negative impacts of their chosen innovation with a focus on social, cultural, environmental, economic, and global impact.	1-2 hours
3 – Examine Responsibility	Students will examine to what extent their chosen innovation is socially responsible with a focus on accessibility and equity.	1-2 hours
4 – Create a Better Future	Students will brainstorm ways they could make changes to the innovative to make it more ecology sound, socially just, and/or accountable to the people.	2-3 hours

4. **Reflective Writing (optional)**: At the end of the unit, students will complete an open-ended option reflective writing exercise focused on the Module content.

Required Readings/Media

Innovation

Learn a bit about innovation by reading the article and watching the TEDx talk. **What is the difference between Innovation & Invention? Which of the 10 key points of innovation resonate with you the most, and why?**

- Article: Innovation vs. Invention: Make the Leap and Reap the Rewards from *wired.com*.

- TEDx talk: The Art of Innovation | Guy Kawasaki (21 min)

Social Responsibility

The following articles highlight the social responsibilities of innovators, engineers, and designers. Social responsibility includes environmental protection, human safety, and the promotion of social justice. **As you review these materials, make a list of 1-2 specific examples of the social responsibilities of innovators, engineers, and designers.**

- YouTube Video: A Practical Guide to Responsible Innovation (3 min)
- Article: Designing the Future by Eva Kaplan-Leiserson from National Society of Professional Engineers. In this 2015 article, the author discusses the broadening responsibilities of engineers in considering the long-term impact of technological progress on societal change.
- Article: Fools for Tools: Why Engineers Need to be Philosophers by from the Chronical of Higher Education (2014). *Note: need to sign up for a free account to view article*

Presentation

Refer to “Global Impact of Design & Innovation” PowerPoint presentation found in the Resource Section.

Class Activities

- For Students: refer to "Responsible Innovation Class Activities" document

Reflective Writing Exercise (optional)

Have students reflect on the following questions by writing a 1-2 page paper using the following prompt: ***Summarize your experience with this content. What did you learn that was surprising to you? What do you want to learn more about? What questions do you still have?***

References:

Angela R. Bielefeldt (July 11th 2018). Professional Social Responsibility in Engineering, Social Responsibility, Ingrid Muenstermann, IntechOpen, DOI: 10.5772/intechopen.73785.

Camille Birch, Celina Gunnarsson, and Dianne Grayce Hendricks. "Work in Progress: Science and Engineering for Social Justice: Curriculum Development and Student Impact." *American Society for Engineering Education Annual Conference, Tampa, FL*. 2019.

N. DeJong-Okamoto, J. Rhee, and Nikos J. Mourtos. "Incorporating the Impact of Engineering Solutions on Society into Technical Engineering Courses" Global Journal of Engineering Education (2005): 77-87.

JB Godhade, ST Hundekari. "Social responsibility of engineers." International Journal of Academic Research and Development (2018), 3:2, 125 – 126.

Donna Riley. (2008). Engineering and social justice. *Synthesis Lectures on Engineers, Technology, and Society*, *3*(1), 1-152.

Student Evaluation Questions

Name: _____ **Date:**_____

	Excellent	Very Good	Good	Fair	Poor	Very Poor
Clarity of Module goals and objective was	☐	☐	☐	☐	☐	☐
Challenge level of class activity work was	☐	☐	☐	☐	☐	☐
Usefulness of material presented was	☐	☐	☐	☐	☐	☐
Organization of the Module was	☐	☐	☐	☐	☐	☐
The overall Module was	☐	☐	☐	☐	☐	☐

Author Bios

Jill Davishahl is Assistant Professor and First Year Programs Direction in the Engineering + Design department at Western Washington University. Jill's teaching, service, and research activities focus on enhancing the first year student experience by providing the foundational technical skills, student engagement opportunities, and professional skill development necessary to improve success in the major, with emphasis of supporting traditionally underserved student populations. Her current research focuses on creating inclusive and equitable learning environments through the development and implementation of strategies geared towards increasing student sense of belonging. Jill aims to motivate students to explore engineering, teach them to be curious and inventive, and help them find a career in whatever realm will allow them to make the world a better place. She imagines a world where people from diverse backgrounds collectively design, create, and build a new reality that supports the greater good by leveraging and applying their intellectual curiosity, innovative intelligence, and analytical skills.

Dr. John Misasi is an Associate Professor of Plastics and Composites Engineering at Western Washington University. John focuses his teaching and research on the relationships between the structures, processing, and properties of industrially relevant polymers and composites. His passion, however, is in educating next-generation engineers and scientists about sustainable materials and recycling technologies through hands-on curriculum and meaningful research experiences. This philosophy has led to successful collaborations with plastics, composites, and recycling industry behemoths (Nike, Boeing, Safran Aerospace) and start-ups (Vartega, Ocean Plastic Recovery Project) alike. John's ultimate goal with his teaching and research is to make the world a cleaner, more sustainable, and overall groovier place to be.

The Global of Design and Innovation
Responsible Innovation Class Activity

Total Estimated Time: 5-8 hours (can be split up over multiple days, weeks, or months)

Suggested Group Size: 3-4 students

Managing Group Work:

Successful group work means that all your teammates contribute to one another's learning and build knowledge by sharing ideas, questions, and thoughts

Assign team members the following roles (take your role seriously, but also allow conversation to happen):

- **Monitor:** check assignment expectations; watch clock; move discussion along
- **Scribe:** record group contributions
- **Reporter:** share out with the larger group

Part 1: Explore a Recent Innovation

Instructions:

1. **Choose an Innovation:** Together with your team, choose an innovation from the list below. Choose something you are interested in learning more about.

2. **Learn:** Familiarize yourself with the innovation by reading over provided articles.

3. **Conduct Additional Research:** Find 1-2 relevant and recent readings/media (articles, research papers, videos, websites, etc.) that discuss interesting and unique aspects of your chosen innovation.

4. **Compile:** Summarize what you learned during the research by completing the table below.

5. **Present:** Optional – present what you learned to the rest of the class

Innovation:	
Brief description:	
What problem is the innovation trying to solve?	
Additional References:	
Summary of what you learned from your research:	
List 2-3 questions you have about this innovation:	

Autonomous Vehicles

Autonomous vehicles, or self-driving cars, are capable of navigating roadways with little to no human input.

Union of Concerned Scientists: Self driving cars explained. (Jan 2017/Feb 2018)

Seattle Times: Are self-driving cars a solution for Bellevue 1/21/2020

Vox: Why we are still years away from having self driving cars. 9/25/2020

Feature: Semi-autonomous vehicle brings future to Japanese mountain village 10/5/2020

Photo 1 Source: https://english.kyodonews.net

Photo 2 Source: http://seattletimes.com

The Mechanical Tree

An Arizona State University & Silicon Kingdom Holdings collaboration.

The “mechanical tree” uses discs made of sorbent to absorb CO2 from the air and is 1000 times more efficient than a regular tree. A cluster of 12 disks can suck a metric ton of the gas out of the atmosphere every day. During regeneration, the disks are lowered inside the bottom container. Inside the chamber, the CO2 is released from the sorbent. The gas is collected, purified, processed and put to other uses.

ASU: Powerful 'mechanical trees' can remove CO2 from air to combat global warming at scale 4/19/2019

Reuters: Do “mechanical trees” offer the cure for climate change? 4/29/2019

Photo Source: https://asunow.asu.edu

Swallowable Electronics

An electronic pill that is equipped with sensors (temperature, pressure, pH, etc) and ingested by a patient. It then gathers information about the digestive system as it travels through it, transmitting the information to a receiver worn by the patient.

Example: The PillCam, also known as capsule endoscopy, is a powerful diagnostic tool that patients swallow and it capture pictures of their small intestine.

Chemical & Engineering News Swallowable electronics could be the future of medical devices(10/16/2017)

UTSW Medical: The PillCam goes on a fantastic voyage to help diagnose GI bleeding 10/9/2019

Photo source: **Medtronic plc**
https://www.royalfreeprivatepatients.com/treatments/pillcam/

The Hippo Roller

https://hipporoller.org/

Although not a recent development, the hippo roller is a good example of a low-tech innovation that has positively impacted many people and is continuously being updated to better meet the needs of communities.

The Hippo water roller, or Hippo roller, is a device used to carry clean water more easily and efficiently than traditional methods, particularly in the developing world and rural areas.

Fast Company: Balancing Tradeoffs: The Evolution of the Hippo Roller (7/14/09)

RCE Blog: 3 innovation lessons from the Hippo Water Roller story (7/5/16)

Photo source: Hipporoller.org

"e-OPRA" Prosthetic

Prosthetics can be challenging as they are often uncomfortable and clumsy, but a company called Integrum is seeking ways to improve the user experience. Their basic OPRA system anchors directly to the bone via osseointegration, which avoids the sores and infections associated with traditional socket prosthetics and enables greater mobility. Their new e-OPRA system adds a two-way electrode system that enables patients to both control the limb with their brain and feel things their prosthesis touches. Plus, the electronics sit inside a tube within the device, avoiding the need for surface electrodes that can get messed up by sweat. *[Source: Popular Science article: The 100 Greatest Innovations of 2020]*

Upgrade your OPRA implant system to the e-OPRA (company website)

Center of Rehabilitation, UMCG Groningen, the Netherlands, introduces the OPRA™ Implant System and Targeted Muscle Reinnervation (4/2021)

Photo source: https://integrum.se/opra-implant-system/e-opra/

Art Clinic, Center of Excellence in the Nordic countries, has treated its first patient with Integrum's OPRA Implant System (3/2021)	

Part 2: Investigating Impact

Guiding Question: What are the social, cultural, environmental, economic, and global impacts of the innovation?

Instructions:

1. Write the name of your chosen innovation in the table below.
2. In your teams, spend some time discussing the "**guiding question**" listed above.
3. For each category, summarize 2-3 potential positive and negative impacts of your innovation.

	Innovation: _____	
	Positive Potential Impacts	**Negative Potential Impacts**
Social		
Cultural		
Environmental		
Economic		
Global		

Follow-up group discussion: New innovations can have both positive and negative impacts. Sometimes, negative impacts are not realized until it is too late.

- Share: Each group will share the most concerning potential negative impact of their chosen innovation with the class.

- Discuss: Why is it important to have diverse perspectives when designing?

Part 3: Examine Social Responsibility

Guiding Questions: How does this innovation impact the whole of society? How can we improve equity and accessibility? How can we reduce discrimination? How do we eliminate bias? How do we reduce historical or social inequities?

Instructions: In your teams, spend some time discussing the "**guiding question**" listed above. Answer the below questions, focusing on your chosen innovation.

Question	Answer
Is there something about the design of the product that excludes populations?	
Is there something about the production or use of the product that negatively affects people or the environment?	
Who reaps the benefits of this innovation?	
Who suffers the costs of this innovation?	

Follow-up group discussion:

- Share: Each group will summarize the answers to these questions.
- Discuss: Would you consider these innovations to be socially responsible? Why or why not?

Part 4: Creating a Better Future

Guiding Question: How might we design in a way that is accountable to the people, ecologically sound and socially just?

Instructions: In your teams, spend some time discussing the "**guiding question**" listed above. Together as a team, come up with 2-3 ways you could **change the design** of your product to make it more ecologically sound, socially just, and/or accountable to the people. Summarize your work using the table.

Design Change	Explanation of Design Change	How does this change make the design more socially responsible?
1		
2		
3		

Follow-up group discussion:

- Share: Each group will share their top design change solution

- Discuss: Is it possible to meet the needs of all people and all of society? What happens when we can't?

The Global of Design and Innovation
Responsible Innovation Class Activity – Instructor Notes

Total Estimated Time: 5-8 hours (can be split up over multiple days, weeks, or months)

Suggested Group Size: 3-4 students

Note: This is an open-ended assignment for which there is no set solution. The notes below are intended to help guide you and your students through this activity.

Part 1: Explore a Recent Innovation

The list of innovations is provided to get you started. Feel free to add others or to have students pick their own. If you have students choose their own, be sure to give them ample time to do research.

Part 2: Investigating Impact

This activity can be challenging for students to really dig into. Some instructors like to narrow the scope a bit to focus on a particular aspect of the product or its design.

You may want to consider focusing on one or more of the following aspects of design:

- Material Choice - What materials is the product made from?
- Manufacturing
    - Where is the product made?
    - How the product is made?
    - Who is doing the work?

- Product Design
    - Who is the intended user?
    - Who is affected by the design?
    - Who reaps the benefits?
    - Who suffers the costs?
- Life Cycle
    - How long is it designed to last?
    - Consider impacts during the entire life cycle: from research to obsolescence.
    - What happens when the product is no longer being used as designed?
- Politics & Policy
    - What are the politics behind this innovation?
    - What policies may impact the use, distribution, disposal, etc.?

Part 3: Examine Social Responsibility

This part of the assignment really benefits from a group discussion. Give ample time for students to share what they have learned.

Part 4: Creating a Better Future

Students typically find this assignment to be fun and it always amazes me with the things they come up with as suggested design changes. If desired, this could be modified to include a student presentation (we suggest a poster format) to share out their design ideas.

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