Engineering Students' Perceptions and Preparedness for Globalization

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Introduction

Do engineering students realize or appreciate the scale and scope of their profession? Do they know their future products and designs will involve a massive global community? I set out to understand how students perceive globalization and help them improve their understanding of the global relationship between engineering and society. In parallel, I want to help my students prepare for a globalized world and to start with a mindset that it isn't necessarily good or bad; it just is. Since it exists, what can we do with it? This project uses globalization as a tool in the engineering classroom to help engineering students concretize globalization by exploring its inertia, its pros and cons, and how to prepare to be an engineer in a globalized world.

University of Portland (UP) is a primarily undergraduate and comprehensive institution with four schools (engineering, business, education, and nursing) and one college (sciences, social sciences, and humanities). The academic experience combines a liberal arts core curriculum, the Catholic Intellectual Tradition, and the students' major-specific educational requirements. The globalization/trade module is incorporated into an engineering economics course. Mechanical, civil, and electrical engineering students take the course – generally in their 3rd and 4th years. The student body is almost entirely traditional-aged college students (18–22 year-olds) from the United States with little to no professional work experience. In general, their worldview is still somewhat limited, so specific attention to global engineering is necessary.

I was inspired to develop this project by the modern classic "The World is Flat" by Thomas L Friedman [1]. After its publication, Friedman's work generated much interest in engineering education, inspiring entire conference sessions [2-4] and panels [5-6].

Friedman [1] discusses how globalization has profoundly impacted engineering by leveraging technological advancements like the Internet and workflow software to enhance communication and collaboration. This has led to more integrated global supply chains, with engineering tasks often outsourced to countries with specialized skills, making the profession more interconnected. Engineers are encouraged to continuously innovate and adapt to new technologies and methodologies to remain competitive. Additionally, collaboration tools have become crucial for modern engineering projects, which frequently involve teams spread across different countries.

Friedman [1] also discusses how engineers support globalization by developing essential technological infrastructure like the Internet and transportation systems. Their innovations drive efficiency and productivity across industries, enabling new products and processes to be shared globally. Engineers also design and manage complex global supply chains, ensuring efficient manufacturing and delivery across countries. Standardization of engineering protocols facilitates international collaboration, while their focus on sustainability addresses global challenges like climate change and resource depletion. Engineering and globalization are inextricably intertwined.

For many, globalization is not a good thing. There are many examples to draw from. Lodigiani [7] summarizes the argument by describing that globalization frequently reinforces historical

inequalities instead of reducing them. Development initiatives and foreign loans can lead to dependency, sustaining neo-colonial power dynamics. Additionally, transnational corporations significantly contribute to these inequalities through exploitative practices. Riegert [8] describes the intertwined phenomena of neocolonialism and globalization and their impact on the exploitation and underdevelopment of African nations. It explicitly explores economic exploitation caused by investments, trade, exporting raw materials, and importing manufactured goods. Many would not equate globalization and colonialism, but it is fair to say it is a continuation. If left unchecked, the line will be even thinner.

Mariasingam *et al.* [9,10] discuss how global business trends reshape workforce needs and engineering education. Future engineers must adapt to globalization, outsourcing, and new technologies. Emerging economies like China and India are producing more trained engineers and hosting multinational R&D facilities. Developed economies face a shortage of skilled engineers, increasing competition for talent. Globalization requires engineers to work in diverse, multinational teams; an aging population worsens this shortage. Engineering curricula should include global perspectives, social awareness, lifelong learning, and business skills. Effective education also needs international collaboration with institutions and industry.

Warnick [11] writes that engineers must develop a global mindset by understanding cultural norms and avoiding ethnocentrism. They should appreciate and adapt to diverse cultures, understand global changes and their implications, and communicate effectively across cultures verbally and non-verbally. Proficiency in English and at least one other language is essential. Additionally, engineers should know different cultural contexts in business and engineering, be able to work effectively in international settings and collaborate in multicultural and multilingual teams. These competencies are crucial for success in a global engineering environment.

One of the most significant works on this topic is the report from the National Summit Meeting on the Globalization of Engineering Education [12]. The first relevant takeaway regards the urgency of global training for engineering students because of global problems requiring global collaboration (climate change, poverty, immigration, etc.) and global opportunities (fusion energy, space exploration, sustainability, etc.). The summit report concludes by offering the Newport Declaration, stressing the need for and urgency for a more global engineering education.

Parkinson et al. [13] offered a comprehensive description of global competence with thirteen dimensions. It highlights the importance of cultural appreciation and effective cross-cultural communication, emphasizing familiarity with various countries' histories, governments, and economic systems. It underscores the value of conversational and professional proficiency in a second language and the ability to work in or lead diverse teams. Ethical considerations arising from cultural differences, understanding these differences in product design and engineering tasks, and recognizing the interconnectedness of the global economy are also crucial. It also includes exposure to international supply chain management, intellectual property, liability, business practices, and practical global experience. Finally, it encourages viewing oneself as a global citizen and appreciating worldwide challenges.

I worried that our students hardly understood globalization or oversimplified it into ‘good’ or ‘bad.’ I was sure they generally do not appreciate the profession’s role. Engineering is using

technology to solve problems, and engineering students often laser-focus their work on the technical aspects of technology. The reality is that technology is deeply intertwined with the social, economic, governmental, and environmental spheres. I used this research project to intervene in their laser focus. The novelty is the student-generated themes below, indicating that they have broadened their view.

Methodology

The students perform an independent research project to explore globalization's impact on a product, company, industry, or community. Table 1 presents a taxonomized list of topics to highlight the types of student interests. It is sometimes hard to distinguish between a product and an industry, so I organized it based on scale or specificity. For example, products are generally 1) specific, named, and branded or 2) fundamentally the same no matter who makes them (i.e., facial tissue is a product, and so is Kleenex).

Table 1: Globalization Topics as Selected by Students

Consumer Goods
Apple
iPhone
VisionPro
Nintendo GameCube
smartphones
consumer electronics
cosmetics
fast-fashion

Healthcare
insulin
medical linear accelerators
illegal drugs
medical devices
pharmaceutical
prosthetics

Retail
Amazon
Temu
e-commerce
dropshipping

Travel & Culture
tourism in Haiti
tourism in Hawaii
tourism and construction in Hawaii

Transportation
Ford Mustang
diesel engines
EV batteries
lithium
cruise liners
automotive
electric vehicles
shipping

Manufacturing & Construction
timber
2x4
concrete
maquiladoras in Mexico
welding
construction

Sports & Outdoors
mountain biking
baseball
rock climbing
skiing
footwear
sneakers in Portland, OR
Nike
Air Jordan
Adidas Parley
soccer balls

Aerospace & Defense
US Army
Lockheed Martin
Boeing
body armor
drones
spacesuits
cyber-warfare
aviation

Places
Hong Kong
Dubai, UAE
Seattle, WA
San Francisco, CA
Ancient Rome
Oahu, HI
Golden Gate Bridge
Anchorage, AK

Agriculture & Food
Spam
Pacific salmon
Red Bull
ice
black pepper
Coca-Cola
marzipan
salt
Nutella
coffee
food
indigenous fisheries
meat packing in America
fishing in Dutch Harbor, AK
sugar in Hawaii
pineapples in Hawaii
coffee in Hawaii

Art & Entertainment
streaming music
Spotify
digital photography
video games
zoos
Six Flags Theme Parks
Disney
Martin Guitars

Energy & Environment
water
water treatment
water & sanitation in developing countries
solar
environment
oil & gas

Technology
artificial intelligence
GPUs
semiconductor
wireless
personal computers
tech in Silicon Valley

Legend
Combo - Industry & Community
Product
Company
Industry
Community

As you can see from Table 1, the students chose a wide range of topics for their papers. I gave them full autonomy in selecting, which I found to be the first important takeaway from this

study. The students choose something they care about, which makes it more relevant and interesting to explore. As you peruse the list, you will see many interesting topics. I want to highlight a few to offer some context and acknowledge that some students thoroughly engaged with their topic.

- Fast fashion: a few students selected this topic because they were interested in contemporary and affordable clothing. They had an idea of the global nature of these brands (e.g., Zara, H&M, or Shein), but their curiosity about the scale and scope warranted a deep dive into the industry.
- UP has a significant student population from Hawaii, so many students focused on their home state for this project. Students tended to pick topics based on Hawaii's more prominent industries of tourism and food/agriculture (sugar, pineapples, and coffee). One student focused on the time during the COVID-19 pandemic and how tourism struggled while construction thrived.
- My civil engineering students often mention that branded products or well-known companies don't drive their field. However, many selected topics are inherent to their industry (timber, 2x4, concrete, environment, and water/sanitation).
- Since our university is in Portland, Oregon, many students focused on footwear (Nike/Air Jordan and Adidas Parley) and the overarching sports/outdoor industry. Students were intrigued by the history of the footwear segment, including sweatshops and child labor in manufacturing facilities outside the US.
- UP has a significant ROTC program (Air Force and Army). Many of our students will enter the aerospace and defense industries upon graduation, so several chose related topics for this project.
- One student who grew up on the border of Texas and Mexico chose to focus on the *maquiladoras* of Mexico, which grew to prominence after the United States passed NAFTA in 1994 [14].
- Many students chose to write about food, most likely because food is the most straightforward way for most to experience globalization first-hand. In one specific case, a student who wrote about Nutella reported a cocoa farmer who had never tasted a chocolate bar because it was too expensive.

The variety and specificity of topics indicate that our students' curiosities are rampant when given a chance to explore in an open-ended way. The insights they learned when given a wide-open field of inquiry were both meaningful and impactful on a large and small scale.

Once the students have a topic, they prepare a research paper that responds to the questions/prompts in Table 2.

Table 2: Prompts Used in the Individual Research Papers

1	Pick a product, industry, or community and describe it briefly.
2	What is the history of that product/industry/community in the US?
3	What is the role globalization plays in that product/industry/community?
4	How has globalization/trade affected that product/industry/community positively?
5	How has globalization/trade affected that product/industry/community negatively?
6	How might (or has) a trade war impacted this product/industry/community?
7	How is an engineer involved in this product/industry/community?
8	How can the engineer of the 21st century be prepared for a global economy?

Approximately two weeks after students submit the research papers, we dedicate a class session to debriefing on the overarching topics of globalization and trade. In this session, the students are divided into groups. Each group is asked to discuss the following questions (Table 3) and summarize their discussion into a single 'best' response to each question. The responses are collected, and the class collectively generates a list of responses to each question.

Table 3: Prompts used for In-Class Discussions

1	Why is globalization/trade good?
2	Why is globalization/trade bad?
3	How are we, as 21st-century engineers, impacted by a global economy? How do we have an impact? How will you prepare?

Results

As described above, the results of this analysis are student-generated. The students collectively generated responses to the prompts posed in (Table 3). These themes indicate an improved understanding of globalization and how the engineering profession interacts with a global society. Table 4 presents the themes, and each is described in the text that follows.

Table 4: Summary of Student-Generated Themes Regarding Globalization/Trade

Positives	Negatives	Preparing Engineers
• Economic Benefits • Innovation & Technology • Societal & Cultural Benefits • Peace & Cooperation • Opportunities & Development	• Economic Impacts • Environmental Concerns • Exploitation & Inequality • Political & Social Impacts	• Communication & Cultural Skills • Lifelong Learning & Adaptability • Global Awareness & Preparedness • Ethical and Responsible Engineering • Global Economy & Competitiveness

Positives of Globalization and Trade

Economic Benefits: An expanded market leads to more products and innovation, creating more jobs and stimulating economies. Companies hiring internationally can benefit both economies involved. This economic boost results in better product accessibility at lower prices, making goods cheaper and more available for consumers. Additionally, it allows companies to expand into new markets and provides food to regions unable to grow certain crops due to climate or soil conditions. Different countries' unique resources and specialties further enhance this global market dynamic.

Innovation and Technology: Increased competition drives technological advancements and fosters innovation. Different perspectives lead to greater creativity, and ideas flourish when diverse minds collaborate. Sharing ideas and cultures promotes innovation. Globalization and trade open markets, advance industries, and enhance competition and technological progress. Globalization boosts economies, encourages competition, and increases productivity by spreading ideas and resources globally.

Societal and Cultural Benefits: Cross-cultural exchange fosters international development and improvements in the developing world by sharing cultures and ideas. This exchange creates connections between different regions and cultures, allowing developing countries to learn from others' experiences and avoid past mistakes. It boosts the economies of underdeveloped

countries, promoting tourism, trade, and access to higher-end products. Sharing ideas and cultures also drives innovation and development.

Peace and Cooperation: Economic interdependence reduces the likelihood of war, as countries tied together economically are less inclined to engage in conflict. This promotes global cooperation, peace, and growth. Collaboration between nations for mutual benefit, including trade partnerships and political alliances, fosters a sense of shared goals and actions. Such partnerships can significantly improve the well-being of billions, potentially reducing or ending poverty.

Opportunities and Development: Globalization creates more opportunities for both domestic and international engineers, leading to increased efficiency on a global scale. Ideally, this results in consumers getting the best products at the best prices and greater awareness of global events. Both consumers and companies stand to benefit from these advancements.

Negatives of Globalization and Trade

Economic Impact: The issues of income inequality and job loss are significant concerns, particularly in the US and countries with higher labor costs and underperforming education systems. Both high-skill and low-skill workers are affected. Larger businesses tend to monopolize industries, making it difficult for smaller businesses to survive and compete with global corporations. This economic control can lead to a situation where one country could potentially cripple the world by controlling the supply of a critical product. As jobs and income shift from some countries to others, monopolies force out smaller businesses, leading to overconsumption and misuse of resources.

Environmental Concerns: Globalization raises significant environmental concerns, including exploiting both the environment and people. The transportation of goods increases monetary and environmental costs, contributing to a larger carbon footprint. As globalization leads to more products being shipped, the environmental impact of each product grows, resulting in increased waste and harm to the environment. Companies often prioritize financial gains over environmental responsibility, exacerbating these issues.

Exploitation and Inequality: Globalization often leads to the exploitation of the developing world, where workers are pushed to produce more for less pay, sometimes under unethical conditions such as child labor or enslavement. Companies capitalize on poverty, prioritizing profit over people, which normalizes various forms of exploitation, including environmental and cultural. This imbalance of power, driven by greed and control over natural resources, results in sweatshops and other exploitative practices that would not exist without globalization. While some argue that any job is better than none, this system leaves much room for exploiting labor and ideas, lacking adaptability and fairness.

Political and Social Impact: Globalization can lead to trade wars and international dependency, exploiting companies politically and through labor and causing cultural changes as countries impose their languages and traditions on others. Conflicts over resources like oil, gold, and water can arise, reminiscent of colonization. A foreign country that controls raw materials and tariffs will have significant market power over American companies. Without regulation, local economies may suffer, benefiting big companies and the global economy at their expense.

Preparing to be an Engineering in a Globalized World

Communication and Cultural Skills: Developing various communication skills is essential for fostering effective interactions. This includes mastering the engineering language and building a cross-cultural skillset. By exporting and importing culture and knowledge, individuals can broaden their perspectives and enhance their understanding of different viewpoints. Considering differing views is crucial for creating a more inclusive and collaborative environment.

Lifelong Learning and Adaptability: Learning new things is crucial for personal and professional development. Embracing lifelong education and continuous learning helps individuals stay informed about technology and the world. It's important not to be complacent; staying up-to-date and aware of global trends ensures one remains relevant and adaptable. Additionally, it's essential not to live in a vacuum, as engaging with diverse perspectives fosters growth and innovation.

Global Awareness and Preparedness: Staying informed and current on international affairs, needs, and products is essential for anyone involved in engineering. Having a solid knowledge of global economics and politics and understanding their impact on engineering is crucial. Cultural education and awareness of current affairs and the international landscape are also important. Being ready to adapt to changing global needs, such as shifting demands and supply chains, and learning about more languages and cultures is vital. Additionally, preparing for trade wars, which will influence design choices, is necessary for staying competitive and relevant in the field.

Ethical and Responsible Engineering: When determining if a product is worth its price point, it's essential to conduct due diligence while considering ethical issues and the needs of other societies. Globalization provides us with everyday products, but ethical considerations must be maintained. Companies being responsible for their actions can improve product quality, reduce global environmental impact, and enhance working conditions for employees. Engineers must be more aware of their actions and their ethical implications. A conscientious engineer can mitigate some of the adverse effects of globalization by considering the overall costs and impacts when selecting materials and making design decisions for a product.

Global Economy and Competitiveness: Adapting to technological changes and the global environment is crucial for engineers, who should explore opportunities abroad and within the global economy. The competitive landscape requires engineers to be competitive worldwide. This competition can potentially limit companies with monopolies on products. To prepare for a global economy, it's important to accept new ideas, stay engaged, and promote environmentally positive practices. Balancing local and global products is essential. When starting a business, consider international factors and competition that could impact development. Given its scale and scope, economic justice, environmental protection, and worker protection are necessary for thriving in the global economy.

Limitations and Issues

The work described in this research article has inherent limitations and issues. As I continue to work on this project, I will continue to improve results in these regards:

- A comprehensive assessment model would evaluate students' understanding of globalization, critical analysis, research quality, communication skills, ethical and cultural awareness,

practical application, lifelong learning, collaboration, innovation, and reflective practice. This model uses detailed rubrics and constructive feedback to ensure students are well-prepared for a globalized engineering profession.

- To improve the paper with more rigorous research, I would expand this to a mixed-methods study by incorporating quantitative and qualitative questionnaires and case-study interviews. I would expand the comparative analysis with control groups and the population of students participating in a student. This will provide a more robust and nuanced analysis of engineering students' perceptions and preparedness for globalization.
- I would incorporate validated prompts. I would expand the questions to incorporate existing literature and refine prompts to analyze globalization's positive and negative impacts, identify essential skills for global engineers, and emphasize ethical considerations and cultural awareness. This will guide students in exploring globalization's complexities and their role in a globalized engineering profession.

Conclusion and Discussion

This project set out to improve student's perceptions and preparedness for the global nature of the engineering profession.

The most significant conclusion is that our students explored their interests. The topics they chose were fundamentally related to their interests or future career interests. The variety and specificity of topics indicate that our students' curiosities are rampant when given a chance to explore in an open-ended way. The insights they learned when given a wide-open field of inquiry were both meaningful and impactful on a large and small scale.

First, students conducted an independent research project exploring globalization/trade on a specific product, company, industry, or community. Then, in a vibrant discussion, the students generated themes to describe the positives and negatives of globalization. They also, and possibly most importantly, generated ways they can prepare for a globalized world.

The average student probably knows their products come from a massive global supply chain. I don't think they understand the scale and scope of that chain. This project is supposed to help them improve their understanding. More importantly, I want engineering students to know that they are studying to be further upstream in that supply chain and are responsible for understanding it and being a part of the modern, global world conscientiously.

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