CES323493

Global Engineering Design Tools

Taylor Sharpe
Mortenson Center in Global Engineering
University of Colorado Boulder

Learning Objectives

- Discover the emerging field of Global Engineering
- Learn about the relationship between air quality and health impacts around the world
- Learn how CAD tools and rapid prototyping manufacturing are being used in global engineering
- Learn how we use the interoperability between Fusion 360 and EAGLE to rapidly prototype products that help advance Global Engineering

Description

Air pollution is a global health issue, and affects more than 90% of the world's population. Our team at University of Colorado Boulder, with support from the Autodesk Foundation, has developed air-quality feedback systems and other environmental sensors to help improve public health around the world. We use engineering technology to address global health problems.

In partnership with a team from Autodesk Pier 9, a health-based air-quality feedback system (the desktop lamp featured at Autodesk University's Factory exhibit) was developed using distance design techniques. Fusion 360 software's CAD, CAM, and Render workspaces were used to collaboratively design the product with inputs from team members in multiple cities, and the electronic computer-aided design (ECAD) integration with EAGLE software was used to design the open-source circuit board.

This class will introduce the field of Global Engineering, with specific examples of how we use CAD, ECAD, and CAM to rapidly prototype solutions to global health problems, from Rwanda to San Francisco.

Taylor Sharpe, Mortenson Center in Global Engineering at CU Boulder

Taylor Sharpe is an Environmental Engineering PhD student, doing his research in the Mortenson Center in Global Engineering at the University of Colorado, Boulder. He is also the rapid prototyping lab manager responsible for design, testing and production of impact evaluation technologies. This space is also used to train engineers in rapid prototyping techniques to help transform ideas into products.

Taylor's background is in Mechanical Engineering. He works as a design engineer for SweetSense, Inc., a social enterprise that uses sensor technology to help utilities, governments and other partners improve their service delivery and keep water running. For the last six years, Taylor has been involved in the development and deployment of IoT sensor systems to improve quality of water service delivery, examine impacts of health interventions, and optimize operations and maintenance operations in at-risk communities.

Taylor was recently hosted as an Impact Resident at Autodesk's Pier 9 workshop, with support from the Autodesk Foundation. His PhD research focuses on how to best use cutting-edge design and manufacturing tools to rapidly deploy sensors to measure and improve public health interventions. He's especially interested in how designers can collaborate even across great distances to produce products that are appropriate and useful to partners.

AUTODESK. UNIVERSITY

MORTENSON CENTER GLOBAL ENGINEERING

What is Global Engineering?

Global Engineering, based out of the Mortenson Center at CU Boulder, is an emerging field which seeks to prepare engineers to make meaningful, impactful contributions to global development efforts by serving as the professional engineering analog to Global Health and Development Economics.

Global Engineering envisions a world where everyone has access to safe water, sanitation, energy, food, shelter, and infrastructure. We are concerned with the unequal and unjust distribution of access to basic services, and seek to inform and improve poverty alleviation efforts by applying engineering research tools to identify drivers, determinants, and impactful solutions to increase access to reliable services.

The Mortenson Center trains engineers to develop and evaluate technologies that could have an impact on poverty alleviation – but given the complex systems that lead to and perpetuate unequal access to resources, technological solutions are not enough. Global Engineering students are trained to consider the historical drivers of poverty; to measure the impacts of health and environmental interventions; to learn from the failures of the international development community and apply these lessons constructively.

Global Engineering leverages remote sensing, IoT instrumentation, well-designed impact evaluation programs, and systems science approaches to improve engineers' abilities to positively impact global development programs.

The Mortenson Center at CU Boulder offers a Global Engineering graduate certificate program for MS and PhD students in a number of engineering disciplines, and an undergraduate minor available to engineering students. Student disciplines include civil and environmental engineering, civil systems, water resources, mechanical engineering, and electrical engineering. Certificate focuses include International Development theory and principles, engineering project management, field methods, WASH, humanitarian aid, and household energy.

As part of the Global Engineering Certificate, students are required to develop their professional skills in the field through a practicum placement with one of a network of host organizations which span the breadth of international development, from small NGOs all the way up to influential multilaterals. Recent practicum placements include BuildChange, Water for People, WorldVision, Sanergy Inc., and the World Bank.

Mortenson Center Project Examples

The Drought Resilience Impact Platform (DRIP)

Climate change and unsustainable environmental practices decrease access to clean water sources, and put increasing stress on vulnerable populations in drought-prone regions. Although the severity of the impacts varies regionally, this threat is not limited to low-income countries. There is a pressing need for characterization and monitoring of groundwater resources. Global Engineering faculty, staff and students are working to apply remote sensing, instrumentation, and water resource management platforms to increase drought resilience globally. This effort is applicable both in rural areas where vulnerable populations are heavily impacted by climate change – like East Africa – and in areas where an agricultural economy is reliant on groundwater – like California.

Infrastructure Resilience and Disaster Recovery

In the face of increasing natural disasters, it's more important than ever to understand what factors can mitigate the worst impacts of disasters and how communities can become more resilient. Mortenson Center researchers are contributing to the engineering literature by examining risk reduction strategies in building construction, and by improving decision-making during resettlement and reconstruction efforts.

Sustainable WASH Systems

Water, sanitation and hygiene (WASH) systems have long been a focus of international development, with plenty of engineering effort put towards technologies that could improve public health outcomes. But consistent failures to take a systems-level approach have led to projects with limited staying power. A research group at the Mortenson Center, with USAID funding, is examining how to use systems thinking to improve the sustainability of WASH interventions. The goal is to help local operators improve quality of service delivery, and maintain high levels of functionality where they are needed most.

Case Study: Air Quality Sensors for Global Engineering

What's the issue?

Air pollution is a serious public health issue everywhere in the world.

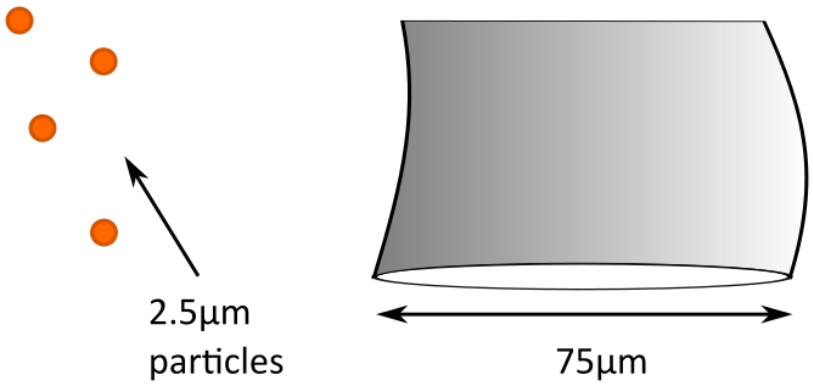
For the significant segment of the world's population who burn wood and charcoal for their daily energy needs, indoor air pollution is one of the leading causes of morbidity and mortality, and especially impacts children under the age of 5. Acute Lower Respiratory Infection is one of the leading killers of children, and air pollution also exacerbates the effects of other environmental health threats.

In emerging markets where significant gains have recently been made regarding wages and jobs, outdoor air quality as a result of industrial activity has a tremendous impact on public health.

In rich economies where environmental regulation has attempted to decrease the threat of air pollution, significant public health impacts are still experienced – in the US alone, particulate matter air pollution is estimated to cause over 85,000 premature deaths annually. In the face of climate change and higher incidence of fires, and as the political system embraces ideologies of de-regulation, the health gains made since the 1970s could soon be diminished.

What's the threat?

A number of air pollution contaminants have been shown to impact health. The type of pollution most strongly associated with health risks is $PM_{2.5}$ pollution, which describes airborne particles smaller than 2.5µm in diameter or smaller. These particles are small enough to be absorbed into the lungs, and are associated with respiratory infection, heart disease, lung cancer, and stroke.



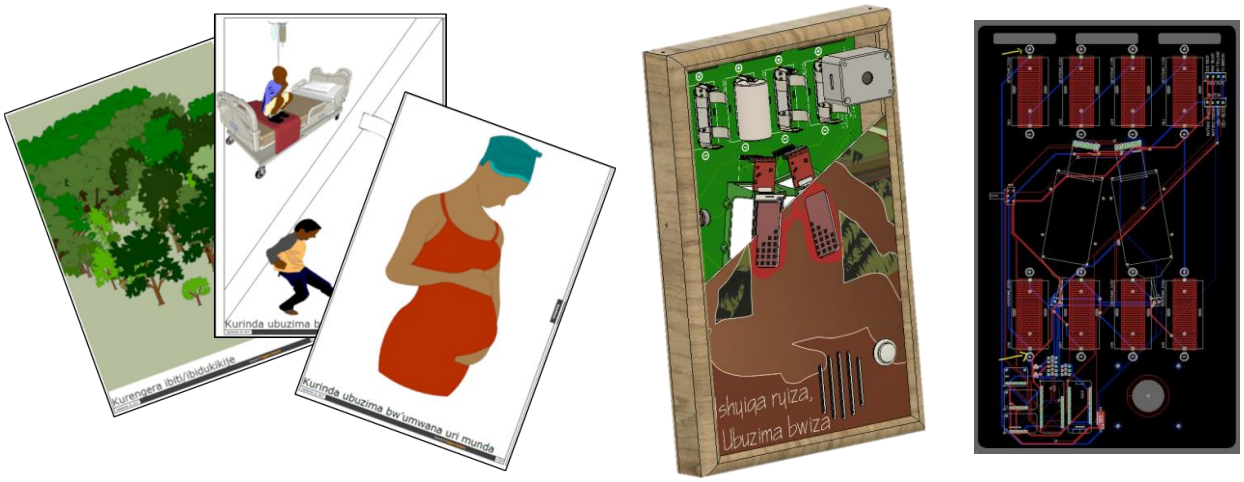
$PM_{2.5}$ PARTICLES ARE SHOWN HERE IN COMPARISON TO THE DIAMETER OF A HUMAN HAIR

What are we doing about it?

Global Engineering researchers are working to turn invisible threats visible. $PM_{2.5}$ particles – only a fraction of the size of a human hair – are small enough that they are invisible to the human eye. But recent advances in sensor technology have allowed for accurate, low-cost $PM_{2.5}$ sensors to be deployed on large scales.

In Rwanda, where the public health impacts of indoor air pollution are severe and where deforestation is a serious environmental threat, Global Engineering researchers are asking questions about whether access to environmental data can improve the success of public health interventions – in this case, whether clean cooking technologies are embraced more when households have access to real-time air quality data. Household air quality sensors co-designed with Rwandese women have been deployed to 100 households, where they provide real-time feedback about the particulate matter pollution in the household.

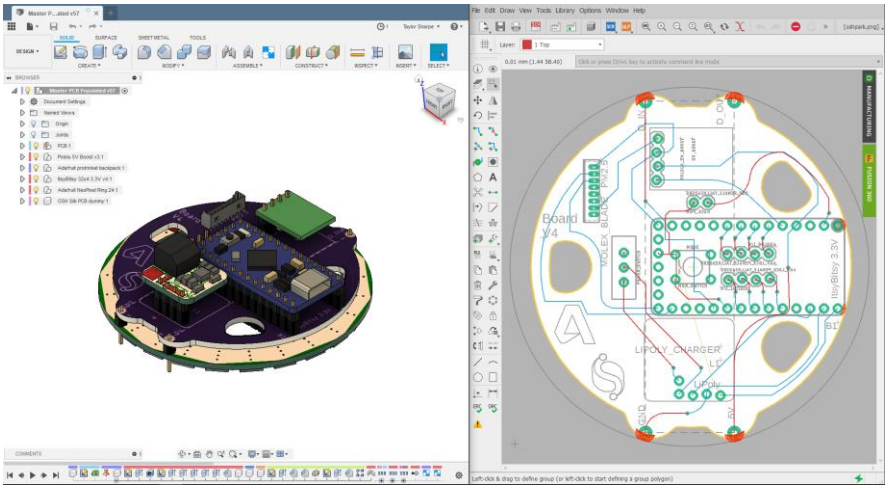
AIR QUALITY SENSORS CAN ANSWER RESEARCH QUESTIONS ABOUT WHETHER ACCESS TO ENVIRONMENTAL DATA IS USEFUL AND ACTIONABLE ON THE HOUSEHOLD LEVEL, AND TO MORE FULLY EXAMINE CORRELATIONS BETWEEN AIR QUALITY, PERSONAL EXPOSURE, AND HEALTH OUTCOMES FOR HIGHLY VULNERABLE POPULATIONS



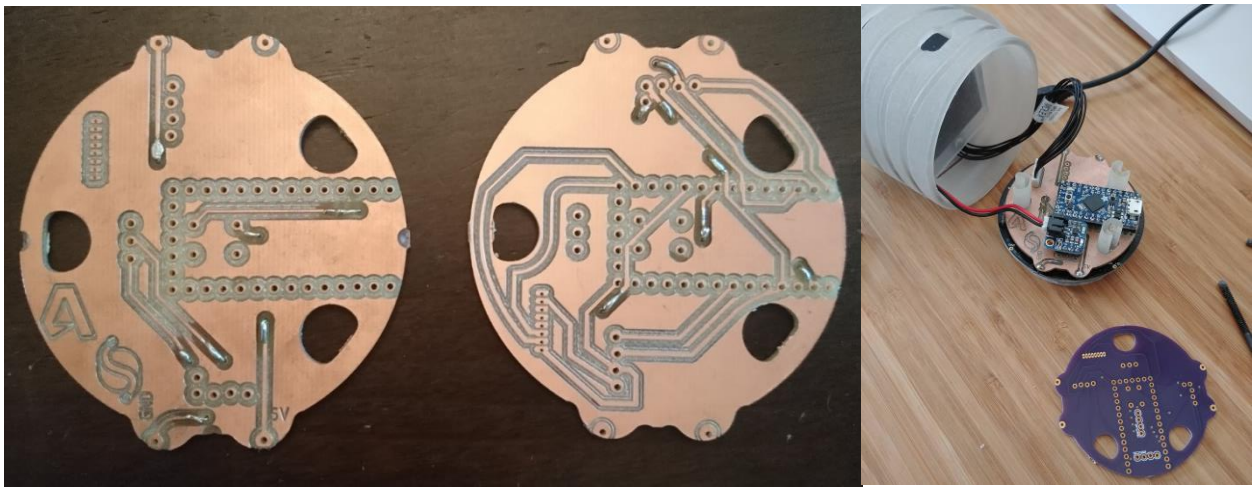
THE SENSORS WERE DESIGNED COLLABORATIVELY FOLLOWING A HUMAN-CENTERED DESIGN PROCESS, WITH ELECTRICAL AND MECHANICAL ENGINEERS PUSHING DESIGNS BACK AND FORTH USING AUTODESK FUSION 360

In the US and the EU, major sources of particulate matter pollution include power production, industrial processes, diesel fuel use, and seasonal wildfires. Populations with less political and economic power are often exposed to higher levels of environmental contaminants. Air pollution has recently been associated with spikes in strokes and heart attacks, and long-term exposure is associated with depression, aggression, and life-long health impacts. The first step to exposing this risk is to make it visible, so we teamed up with engineers and designers at Pier 9 to develop a collaboratively engineered air quality lamp to shine some light on this threat. The main goal is to expose people at AU and the larger online maker community to just one way that sensor technology can give us important information about environmental threats.

DESIGN CONCEPTS WERE SHARED IN THE VIRTUAL WORKSPACE



MECHANICAL AND ELECTRICAL DESIGN WERE SIMULTANEOUSLY COMPLETED BY ENGINEERS IN TWO LOCATIONS – COLORADO AND CALIFORNIA



DESKTOP MILLING MACHINES AND 3D PRINTERS WERE USED TO RAPIDLY ITERATE DESIGNS

THE FINAL PRODUCT OUTPUTS AIR POLLUTION READINGS, COLOR-CODED TO REFLECT RELATIVE HEALTH RISKS. THIS YEAR'S AU FACTORY WILL PRODUCE A MODIFIED VERSION OF THE AIR QUALITY LAMP WITH ADDED IOT CAPABILITIES