Richard Witte Endowed Professorship Report 2020

Joshua Pearce

This last year the Richard Witte Endowed Professorship funds have enabled the **24-member** MOST (Michigan Tech Open Sustainability Technology) research group to tackle a wide range of new ideas. Funds were used to provide materials and supplies **for eight undergraduates** on MacArthur Fellowships, a Link Fellowship, and Young Investigator awards. Funds were also used to support projects from **8 graduate students** and **8 post-docs and several visiting scholar**s as well as some staff time. Out of the 38 peer-reviewed articles published by MOST this year, the Witte Endowment directly helped the research team to publish **24 peer-reviewed articles**, which resulted in preliminary data and exposure that has **helped leverage several million in additional funding including a major new contract with the Federal Government to turn plastic waste into edible food**. The MOST group's general frugality has led it to being probably best known for making extremely inexpensive high-quality scientific tools and low-cost solar energy and the Endowed Professorship has been stretched to maximize scientific impact and media recognition for the betterment of humankind.

Generally, the Witte Endowment was used as support researchers funded by other means by buying their supplies, testing, or random other expenses (e.g. poster printing or postage to ship samples to international collaborators), or as bridge support between grant cycles for specific students. It therefore affected everyone in the 24-member group positively even if it did not directly pay their salaries. This flexibility to apply funds quickly where they were needed was critical. **The Witte Endowment was therefore instrumental in helping Dr. Pearce break the 15,000 citations mark and increase the citation rate to over 2,500 citations per year, which is the highest citation rate in Michigan Tech's history according to Google Scholar**. These works were well received by the media and resulted in several hundred news stories covering 18 major research finding areas.

Most importantly this year during the COVID-19 pandemic the Witte Endowment enabled the group to pivot to do critical research and resulted in six publications as well as helping people both at home and all over the world. For a summary of those articles see MTU Unscripted story.

Details of expenditures:

Labor

- Funded some staff time a small amount of graduate student time (very partial) and mostly undergraduate research time to perform experiments or build equipment. A good example is the funds spent on William's time to do basic GIS analysis for a study looking at greenhouse gas bottlenecks, which was covered by over 20 news sites. It also funded several graduate students when we pivoted to doing COVID-19 research. This research resulted in a raft of publications (detailed below) as well as major news coverage particularly overseas.

Non-Labor

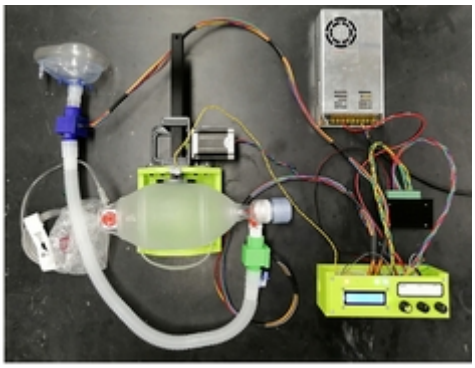
- Non-labor expenses included publishing fees, chem stores chemicals, materials testing and facilities fees (mechanical, XRD, SEM, etc.), mail charges, poster printing, laptop computers, glassware, electronics, mechanical hardware, filament, safety equipment, welding supplies, and other lab supplies. These small expenditures when you need them are critical for rapid scientific progress and the Witte Endowment removed financial pressure even from funded projects as we could just spend money on what it needed to be spent on without going back to funders to reclassify expenses.

Outputs
Student coauthors in bold.

Publications specifically focusing on COVID-19

With Witte Funding we were well-positioned to pivot early and focus on alternatives to ventilators and PPE to help hospitals in need. Our work was covered widely in the press in over 30 news stories including *Yahoo News!* and major regional papers in Michigan Tech's target recruiting markets like the *Houston Chronicle*.

The first review article came out in real-time open access and was read over 30,000 times and has already been cited 38 times this year. This kind of readership and use is extremely uncommon.



1. Joshua M. Pearce. A Review of Open Source Ventilators for COVID-19 and Future Pandemics. *F1000Research 2020, 9:218.* **https://doi.org/10.12688/f1000research.22942.2**
2. **Aliaksei Petsiuk, Nagendra G. Tanikella, Samantha Dertinger, Adam Pringle, Shane Oberloier,** Joshua Pearce. Partially RepRapable Automated Open Source Bag Valve Mask-based Ventilator. *HardwareX*, 8, (2020), e00131 **https://doi.org/10.1016/j.ohx.2020.e00131**

Similarly one of the testing roadblocks in our area was swabs – we developed some that could be 3-D printed, but luckily that supply chain was fixed before we needed to deploy them. The design is finished and they are ready for testing for the next emergency.

3. **Nicole Gallup, Adam M. Pringle, Shane Oberloier, Nagendra G. Tanikella**, and Joshua M. Pearce. Parametric Nasopharyngeal Swab for Sampling COVID-19 and Other Respiratory Viruses: Open Source Design, SLA 3-D Printing and UV Curing System. *HardwareX* 8, 2020, e00135 https://doi.org/10.1016/j.ohx.2020.e00135

We also worked with the Michigan Tech library in manufacturing thousands of PPE to distribute to front line workers, the hospitals and the campus. In doing so we created a new 3-D printer that would allow them to be heat sterilized as well as a system specifically for fire fighters.

4. **Noah G. Skrzypczak, Nagendra G. Tanikella**, and Joshua M. Pearce. Open source high-temperature RepRap for 3-D printing heat-sterilizable PPE and other applications. *HardwareX* 8,(2020), e00130 https://doi.org/10.1016/j.ohx.2020.e00130
5. **Benjamin R. Hubbard** and Joshua M. Pearce. Conversion of Self-Contained Breathing Apparatus Mask to Open Source Powered Air-Purifying Particulate Respirator for Fire Fighter COVID-19 Response. *HardwareX* 8 (2020), e00129. **https://doi.org/10.1016/j.ohx.2020.e00129**

6. Joshua M. Pearce. Distributed Manufacturing of Open-Source Medical Hardware for Pandemics. *Journal of Manufacturing and Materials Processing* 2020, 4(2), 49; https://doi.org/10.3390/jmmp4020049

Other publications by the MOST group directly supported in some way by the Witte Endowment covering solar energy, recycling, open hardware, distributed manufacturing, energy policy and alternative food:

1. **William Lytle, Theresa K. Meyer, Nagendra G. Tanikella**, Laurie Burnham, Julie Engel, Chelsea Schelly, and Joshua M. Pearce. Conceptual Design and Rationale for a New Agrivoltaics Concept: Pastured-Raised Rabbits and Solar Farming. *Journal of Cleaner Production* (in press). https://doi.org/10.1016/j.jclepro.2020.124476
2. **Pierce Mayville, Neha Vijay Patil,** and Joshua M. Pearce. Distributed Manufacturing of After Market Flexible Floating Photovoltaic Modules. *Sustainable Energy Technologies and Assessments* 42, 2020, 100830, https://doi.org/10.1016/j.seta.2020.100830
3. **Adam M. Pringle, Shane Oberloier, Aliaksei L. Petsiuk,** Paul G. Sanders and Joshua M. Pearce. Open Source Arc Analyzer: Multi-Sensor Monitoring of Wire Arc Additive Manufacturing. *HardwareX* 8 (2020) e00137. https://doi.org/10.1016/j.ohx.2020.e00137
4. Joshua M. Pearce. Economic Savings for Scientific Free and Open Source Technology: A Review. *HardwareX* 8, 2020, e00139. https://doi.org/10.1016/j.ohx.2020.e00139
5. **Juan B. García Martínez**, Joseph Egbejimba, James Throup, Silvio Matassa, Joshua M. Pearce, David C. Denkenberger. Potential of microbial protein from hydrogen for preventing mass starvation in catastrophic scenarios. *Sustainable Production and Consumption* 25, (2021) 234-247. https://doi.org/10.1016/j.spc.2020.08.011
6. **B. Ugwoke**, A. Adeleke, S. P. Corgnati, P. Leone, J. M. Pearce. Decentralized renewable hybrid mini-grids for rural communities: Culmination of the IREP framework. *Sustainability* **2020**, *12*(18), 7411; https://doi.org/10.3390/su12187411
7. **Nupur Bihari, Ismo T. S. Heikkinen, Giovanni Marin, Craig Ekstrum, Pierce J. Mayville, Shane Oberloier,** Hele Savin, Maarit Karppinen and Joshua M. Pearce. Vacuum Outgassing Characteristics of Unpigmented 3-D Printed Polymers Coated with ALD Alumina. *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* **38**, 053204 (2020); https://doi.org/10.1116/6.0000178
8. **Alexis S. Pascaris** and Joshua M. Pearce. U.S. Greenhouse Gas Emissions Bottlenecks: Prioritization of Targets for Climate Liability. *Energies 13*(15), 2020, 3932; https://doi.org/10.3390/en13153932
9. **Jacob Franz** and Joshua M. Pearce. Open-Source Grinding Machine for Compression Screw Manufacturing. *Inventions.* 2020, 5(3), 26; https://doi.org/10.3390/inventions5030026
10. **Benjamin R. Hubbard** and Joshua M. Pearce. Open Source Digitally Replicable Lab-Grade Scales. *Instruments* 2020, *4*, 18; https://doi.org/10.3390/instruments4030018
11. **Brindha V.G. Mohan**, Jeyanthinath Mayandi, Joshua M. Pearce, Kottaisamy Muniasamy, and Vasu Veerapandy. Demonstration of a simple encapsulation technique for prototype silicon solar cells. *Materials Letters* 274 (2020), 128028. https://doi.org/10.1016/j.matlet.2020.128028
12. **Theresa K. Meyer, Nagendra G. Tanikella, Matthew J. Reich**, and Joshua M. Pearce. Potential of Distributed Recycling from Hybrid Manufacturing of 3-D Printing and Injection Molding of Stamp Sand and Acrylonitrile Styrene Acrylate Waste Composite. *Sustainable Materials and Technologies.* 25, 2020, e00169 https://doi.org/10.1016/j.susmat.2020.e00169
13. Joshua M. Pearce. Energy Conservation with Open Source Ad Blockers. *Technologies* 2020, 8, 18. https://doi.org/10.3390/technologies8020018
14. **Ismo T. S. Heikkinen, Giovanni Marin, Nupur Bihari, Craig Ekstrum, Pierce J. Mayville, Yuhuan Fei,** Yun Hang Hu, Maarit Karppinen, Hele Savin and Joshua M. Pearce. Atomic layer

deposited aluminum oxide mitigates outgassing from fused filament fabrication–based 3-D printed components. *Surface and Coatings Technology* 386 (2020) 125459. https://doi.org/10.1016/j.surfcoat.2020.125459

15. **Trevor B. Peffley** and Joshua M. Pearce. The Potential for Grid Defection of Small and Medium Sized Enterprises Using Solar Photovoltaic, Battery and Generator Hybrid Systems. *Renewable Energy 148, 2020, 193-204*. https://doi.org/10.1016/j.renene.2019.12.039
16. **Apoorv Kulkarni,** Gian Domenico Sorarù, Joshua M. Pearce. Polymer-derived SiOC Replica of Material Extrusion-based 3D Printed Plastics. *Additive Manufacturing 32,* 2020, 100988. https://doi.org/10.1016/j.addma.2019.100988
17. **Aliaksei L. Petsiuk** and Joshua M. Pearce. Open Source Computer Vision-based Layer-wise 3D Printing Analysis. *Additive Manufacturing.* (36) (2020), 101473, https://doi.org/10.1016/j.addma.2020.101473
18. **Rasoul Bayaniahangar, Shahab Bayani Ahangar, Zhongtian Zhang,** Bruce P. Lee, and Joshua M. Pearce. 3-D Printed Magnetic Soft Magnetic Helical Coil Actuators of Iron Oxide Embedded Polydimethylsiloxane. *Sensors & Actuators: B. Chemical* 326, (2021), 128781. https://doi.org/10.1016/j.snb.2020.128781

There is always a lag between the time research is done and the time it is published and makes greater impact. There are more than a dozen additional Witte-funded (at least in part) articles under review currently as well as grant proposals in preparation or submitted. We are extremely grateful for the **Richard Witte Endowed Professorship**, which has been an enormous help for the MOST research group in aggressively exploring new ideas that would have been impossible otherwise.

Outreach

Research supported by Witte was well received by the media and resulted in several hundred news stories covering 18 major research finding areas. For example, the high temperature 3-D printer was not only covered by domestic media, but also *Sohu*, one of China's largest news sites among many others from Europe and Asia. The 3-D printing industrial press and outlets like *Hack-A-Day* cover the 3-D printing developments regularly. Similarly, the *Photovoltaic Magazine* covers our solar energy research and *Yahoo Finance* covered the economic studies related to solar. Our work is also regularly covered by online media like *Ask*, *Mashable*, and *Medium*.

To help reach and recruit more prospective students, I also published *Create, Share, and Save Money Using Open-Source Projects*. The book was published by McGraw Hill the largest educational publisher. Designed for beginners, this engaging guide is filled with ways to save money by making use of free and open-source technologies on a wide and impressive range of products. The book popularizes a lot of the research funded by Witte and reveals the potential of at-home manufacturing and recycling projects—and even how to score free big-ticket items, including housing and electricity (compliments of solar). All the projects have big money saving in mind, but also big fun!

We are working closely with Educational Outreach to use the book to encourage prospective MTU students to use open source projects as an entrance to a STEM/STEAM major and career.