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Utilizing Partnership Flexibility and Strengths:

Key Elements for Driving 3D Printed Face-Shield Production During the COVID-19 Pandemic

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In early March as COVID-19 cases steadily mounted, questions quickly arose about ways to minimize clinician exposure and to maximize PPE availability by manufacturing and reusing PPE in novel ways to address shortages. These questions coupled with the pronounced lack of N95 masks (among other products) challenged convention and forced the development of new strategies to 1) lengthen the usability window of standard N95-type masks, and 2) provide additional levels of protection.

Clearly, company closures, physical distancing, and the challenge to the medical community from increased patient loads rapidly made new, unprecedented demands on all daily routines. While the challenges that resulted were great on so many fronts, so too was the tremendous catalyst for driving innovation that helped to unite disparate organizations. The resulting innovation that has occurred has been staggering in both magnitude and pace with each output focused on measurably improving the conditions during the pandemic.

The complications in forming cross-sector collaborations are numerous and challenging. While potentially daunting, they enable companies and organizations to leverage invaluable new resources, expertise, and networks that may often create unsurmountable barriers to inhouse-only projects. A collaboration occurred in late March as the COVOD-19 pandemic impact was just beginning to be understood. Dr. Vicky Funanage (Nemours Children's Health System) contacted Dr. Tim Mueller (DuPont & DE Innovation Space) to discuss a project that Nemours had initiated under the direction of Dr. Tariq Rahman, Director of the Nemours Center for Orthopedic Research and Development, to create face shields using 3D printing. Nemours had been assembling disposable face shields from foam and film. However, these were not as robust and were limited due to issues with cleaning. A few plans for 3D-printed face shields were circulating online, but Nemours did not have the ability to 3D print in volume. The face shields would serve two purposes: 1) to be a direct barrier to the transfer of COVID-19 from patient to health care worker, and 2) they would target the critical shortage of N95 face masks in serving as a physical barrier increasing useful life of a typical N95 mask by preventing contamination. Drs. Funanage and Mueller had worked together previously on new technology exploration and quickly decided to address this urgent challenge and to meet the immediate needs of employees and the community. With all the complexity highlighted above, what made this collaboration successful? There are many contributing factors (e.g., resources, technology, communication), but the most impactful was a clear definition of the goal and the rallying of organizational resources to give resolution the highest priority.

The basic design of the face shield was available as a download.[1] Working together, the Nemours and DuPont teams made some rapid modifications, and the DuPont material Zytel®

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3D1000 was chosen for its durability and strength. The goal was to create a reusable shield that could be distributed to frontline health care workers and cleaned as necessary. Creating the final shield had three critical steps:

1) 3D printing and preparing the headband (DuPont team),
2) Cutting the face shield from rolled thermoplastic polymer resin (Nemours and DuPont), and
3) Assembling the three pieces – headband, shield, and elastic band (Nemours).

A finished shield prototype was evaluated by Nemours/Alfred I. duPont Hospital and deemed acceptable, so the next challenge was to scale up the process to create 4,000 face shields in a timely fashion.

This scale of face shield production would require almost 200 one kilogram spools of filament for the 3D printers, and at approximately two hours of print time required per headband, and a lot of printers. Thankfully, DuPont had resin, filament-making expertise, and a 3D printing lab at the Experimental Station that was up to the challenge. A team of scientist and technical support experts was assembled, followed by business, legal, and leadership alignment within 24 hours. This example is one of many that highlights DuPont's commitment to its core values and collaboration in our hometown community[2] during the COVID-19 pandemic. The team discussed creating the shields using injection molding, but the goal was to have immediate impact; to create molds and test them for injection molding would have required 6-8 weeks. Therefore, 3D printing was the preferred choice, and the 12 available printers provided the immediate impact. This temporal requirement was critical as the percentage of Delaware emergency room visits for COVID-19 symptoms peaked on April 12, 2020, which was less than 3 weeks after the onset of the project.

After some initial performance and model adjustments, the team started production and averaged around 120 headbands per day at the Experimental Station. The method was duplicated at other DuPont sites to meet local needs in both Michigan and California, where additional capacity was located. After two months, the Delaware collaboration yielded 3,840 completed reusable face shields that were assembled and distributed to Delaware hospitals and some nursing homes (see Figure 1). As the manufacturing and supply chains for face shields began to catch up with demand, it was decided that it was time to shut down the project; this occurred in early June. Feedback from the medical community has been positive, and an additional 23 rolls of filament were manufactured and have recently been sent to CA to continue the manufacturing locally. Nemours/Alfred I. duPont Hospital for Children has been deploying these shields to clinical personnel, and the face shields have shown to be durable and a lifesaver for the frontline workers.

While it may be some time before we go back to “normal,” there is time to reflect on the innovative environment that fosters ways to leverage skills and resources beyond traditionally defined roles. Existing networks are critical to successful outcomes because the challenges of cross-sector collaborations are only magnified in our world of virtual meetings and long-distance engagements. Critical individuals must serve as connectors to bridge the gaps and create avenues using best practices and must be openly transparent about expectations and capabilities. It is important to present with purpose and create the necessary atmosphere of collaboration to target

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required outcomes. At the project conclusion, not only did this project help our community, it assisted all of those involved to help transition from surviving to thriving, if only a little bit.

Figure 1. Completed face shield

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References

1. Printers, P. R. U. S. A. (n.d.) Downloadable face shield. Retrieved from https://www.prusaprinters.org/prints/25857-prusa-protective-face-shield-rc3/files
2. Dupont. (2020, May). An innovative spirit drives community impact in our hometown community. Retrieved from https://www.dupont.com/news/innovative-spirit-drives-community-impact-in-wilmington-delaware.html